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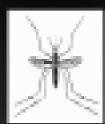

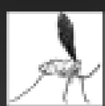

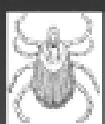

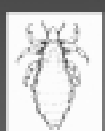

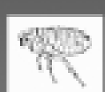

Regional Disease Vector Ecology Profile

North Africa

Defense Pest Management Information Analysis Center
Armed Forces Pest Management Board
Forest Glen Section
Walter Reed Army Medical Center
Washington, DC 20307-5001

Homepage: http://www.afpmb.org

May 2000

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PREFACE

Disease Vector Ecology Profiles (DVEPs) summarize unclassified literature on medically important arthropods, vertebrates and plants that may adversely affect troops in specific countries or regions around the world. Primary emphasis is on the epidemiology of arthropod-borne diseases and the bionomics and control of disease vectors. DVEPs have proved to be of significant value to commanders, medical planners, preventive medicine personnel, and particularly medical entomologists. These people use the information condensed in DVEPs to plan and implement prevention and control measures to protect deployed forces from disease, injury, and annoyance caused by vector and pest arthropods. Because the DVEP target audience is also responsible for protecting troops from venomous animals and poisonous plants, as well as zoonotic diseases for which arthropod vectors are unknown, limited material is provided on poisonous snakes, noxious plants, and diseases like hantavirus.

In this document vector-borne diseases are presented in two groups: those with immediate impact on military operations (incubation period < 15 days) and those with delayed impact on military operations (incubation period > 15 days). For each disease, information is presented on military importance, transmission cycle, vector profiles, and vector surveillance and suppression.

Additional information on venomous vertebrates and noxious plants is available in the Armed Forces Medical Intelligence Center's (AFMIC) Medical, Environmental, Disease Intelligence, and Countermeasures (MEDIC) CD-ROM.

Contingency Operations Assistance: The Armed Forces Pest Management Board (AFPMB) is staffed with a Contingency Liaison Officer (CLO), who can help identify appropriate DoD personnel, equipment, and supplies necessary for vector surveillance and control during contingencies. Contact the CLO at Tel: (301) 295-7476, DSN: 295-7476, or Fax: (301) 295-7473.

Defense Pest Management Information Analysis Center (DPMIAC) Services: In addition to providing DVEPs, DPMIAC publishes Technical Information Bulletins (TIBs), Technical Information Memorandums (TIMs), and the Military Pest Management Handbook (MPMH). DPMIAC can provide online literature searches of databases on pest management, medical entomology, pest identification, pesticide toxicology, and other biomedical topics. Contact DPMIAC at Tel: (301) 295-7479, DSN: 295-7479, or Fax: (301) 295-7483. Additional hard copies or diskettes of this publication are also available.

Other Sources of Information: The epidemiologies of arthropod-borne diseases are constantly changing, especially in developing countries undergoing rapid growth, ecological change, and/or large migrations of refugee populations resulting from civil strife. In addition, diseases are underreported in developing countries with poor public health infrastructures. Therefore, DVEPs should be supplemented with the most current information on public health and geographic medicine. Users may obtain current disease

risk assessments, additional information on parasitic and infectious diseases, and other aspects of medical intelligence from the Armed Forces Medical Intelligence Center (AFMIC), Fort Detrick, Frederick, MD 21701, Tel: (301) 619-7574, DSN: 343-7574.

Disease Risk Assessment Profiles (DISRAPs) and Vector Risk Assessment Profiles (VECTRAPs) for most countries in the world can be obtained from the Navy Preventive Medicine Information System (NAPMIS) by contacting the Navy Environmental Health Center (NEHC) at Tel: (757) 762-5500, after hours at (757) 621-1967, DSN: 253-5500, Fax: (757) 444-3672. Information is also available from the Defense Environmental Network and Information Exchange (DENIX). The homepage address is: <http://www.denix.osd.mil/>.

Specimen Identification Services: Specimen identification services and taxonomic keys can be obtained through the Walter Reed Biosystematics Unit (WRBU), Museum Support Center, MRC-534, Smithsonian Institution, Washington, DC 20560 USA; Tel: (301) 238-3165; Fax: (301) 238-3667; e-mail: <wrbu@wrbu.si.edu>; homepage: <http://wrbu.si.edu/>.

Emergency Procurement of Insect Repellents, Pesticides and Equipment: Deploying forces often need pesticides and equipment on short notice. The Defense Logistics Agency (DLA) has established the following Emergency Supply Operations Centers (ESOCs) to provide equipment and supplies to deploying forces:

> **For insect repellents, pesticides and pesticide application equipment:** Contact the Defense Supply Center Richmond ESOC at Tel: (804) 279-4865, DSN: 695-4865. The ESOC is staffed seven days a week/24 hours a day. Product Manager (804) 279-3995, DSN: 695-3995.
>
> **For personal protection equipment (bednets, headnets, etc.) and respirators:** Contact the Defense Supply Center Philadelphia ESOC Customer Assistance Branch at Tel: (215) 737-3041/3042/3043, DSN: 444-3041/3042/3043.

Every effort is made to ensure the accuracy of the information contained in DVEPs. Individuals having additional information, corrections, or suggestions, are encouraged to provide them to the Chief, DPMIAC, Armed Forces Pest Management Board, Forest Glen Section, Walter Reed Army Medical Center, Washington, DC 20307-5001; Tel: (301) 295-7479, DSN: 295-7479; Fax: (301) 295-7483.

Acknowledgments: The initial draft of this DVEP was prepared by Dr. John B. Gingrich, LTC USA (retired), Dr. Harold J. Harlan, LTC USA (retired), Dr. Peter V. Perkins, COL USA (retired) and Dr. James H. Trosper, CDR USN (retired). Subsequent technical reviews and recommendations were provided by DPMIAC's LTC Richard N. Johnson, USA, COL Phillip G. Lawyer, USA, Capt Daniel J. Mauer, USAF, Dr.

Richard G. Robbins, CDR George W. Schultz, USN, COL Harvey A. Shultz, USAR, Dr. William H. Dees, and Dr. Timothy H. Dickens, CDR USN (retired), as well as by the Armed Forces Medical Intelligence Center.

The taxa presented in the list of species in North Africa were reviewed by experts for the respective groups. Dr. James E. Keirans, Georgian So uthern University, reviewed the ticks. Dr. Robert E. Lewis, Iowa State University, reviewed the fleas. COL Phillip G. Lawyer and Dr. Peter V. Perkins reviewed the sand flies. Dr. Roy McDiarmid, National Museum of Natural History, reviewed the snakes. M AJ Scott A. Stockwell reviewed the scorpions. Mr. James F. Pecor of the US Army Walter Reed Biosystematics Unit reviewed the mosquitoes.

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EXECUTIVE SUMMARY

North African Profile

Geography. North Africa encompasses slightly more than 6 million sq km of land. It is largely flat but includes several ranges of mountains and upland plateaus. The geographic character of each country is unique and varies from mountainous parts of northern Tunisia and Morocco to the arid deserts of southern North Africa, including a large portion of the Sahara Desert. Most of the high ground in this region is found in the Atlas Mountains in northern Morocco, along the Mediterranean coasts of Algeria and Tunisia, the Ahaggar region of southern Algeria and Libya, and in Egypt's Sinai Peninsula. The highest peak, Jebel Toubkal (4,165 m), is located at the western end of the Haut Atlas range, near the center of Morocco. A few peaks remain snow-capped most of the year, including the volcanic crater Canadas (or Pico) del Teide, 20 km in diameter and 3,718 m high, on Tenerife in the Canary Islands. The region is bordered on the west by the Atlantic Ocean, on the south by the southern Saharan desert countries of Mauritania, Mali, Nigeria, Chad and Sudan, on the east by the Red Sea and Israel, and on the north by the Atlantic Ocean and the Mediterranean Sea. Petroleum, mineral reserves (especially phosphates), and tourism are the mainstays of the regional economy. Arid conditions, poor soils, and limited precipitation (especially in areas within the Sahara and away from the coasts) make it difficult for local farmers and herdsmen to produce enough food for countries in this region to feed their own people. Consequently, every country in the region must import a significant portion of its basic sustenance.

Climate. The climate of North Africa is predominately arid. Coastal plains have a Mediterranean climate, with mild winters, when most of the year's precipitation falls, and hot dry summers with little or no precipitation. Wind patterns are chiefly west to east along the coasts and east to west inland. The Canaries Current carries a fairly constant flow of cold water from the North Atlantic southwestward along the coast of Morocco, which moderates the climate of the Canary Islands and reduces the incidence of storms. Zones of elevation stratify climatic conditions on these islands, and this is reflected in floral and faunal patterns. Temperatures in the Sahara Desert reach a high of 44 °C in summer and are frequently accompanied by strong, hot, dust-carrying winds known as the sirocco. These can carry hot air masses and tremendous clouds of dust over large sections of the coastal plains, oases, and mountain foothills, which normally have a Mediterranean climate. These events can also significantly affect the climate of the Canary Islands. Locally, coastal sea or shore breezes often modify temperature and weather extremes along the Mediterranean coast of North Africa. Mountains modify weather extremes along the path of the prevailing winds, especially in the Atlas ranges of Morocco, Algeria, and Tunisia.

Population and Culture. Most of the approximately 137 million people of the North African region are Muslim (primarily of the Sunni sect). The population of every country or territory in this region is at least 90% Muslim except the Canary Islands, where the official religion is Roman Catholicism. The vast majority of North Africans are of

Berber or Arab descent. The ethnic make-up, religious mix and culture of each country vary considerably. The Canary Islands are unique in that their native inhabitants, called Canarios, descended from an ancient race (the Guanches) of light-skinned people and Spanish who invaded these islands in the 1400s. North African countries are rapidly becoming urbanized, and most of the population lives on a relatively small portion of the land within 100 km of the coasts or mountains, mainly on coastal plains, in fertile valleys or near oases. Large cities such as Casablanca, Algiers, and Tripoli have extensive slums and shantytowns. The extremes of population density within the region are greatest in Egypt. Cairo has an average population density of 30,000 inhabitants per sq km, while some Egyptian frontier Governorates average less than 1 person per sq km. As nomadic people move into poorer urban areas, they bring their pastoral habits and their domestic animals with them. This worsens sanitation problems and increases a variety of disease threats. The majority of people in the region are poor and minimally literate. This makes health, sanitation and disease prevention education efforts difficult.

Sanitation and Living Conditions. Sanitation and living conditions throughout the region are generally poor by Western standards. Septic and sewer systems are limited to larger cities, vary in quality, and are poorly maintained. Water treatment and distribution systems are inadequate, contaminated and seldom maintained. Waste disposal is indiscriminate in many areas, especially urban slums. Water and sewer services are largely reserved for the wealthy. Food sanitation is poor, and significant pest and vector populations are common in and near human habitations. These conditions pose serious threats of disease transmission. Housing shortages exist in many cities, and more than one family may share a small home that also shelters domestic animals. Bedouins who move to urban sites often set up their own skin or cloth tents or build huts of sod, sticks and palm frond thatch. These structures provide some degree of protection from the heat, wind and cold (frost is common in many areas on winter nights) but create a significant public health problem.

DIARRHEAL DISEASE

Gastrointestinal infections are highly endemic and are the principal disease threats in both rural and urban areas in North Africa. Fecal-oral transmission from person to person is common, but most infections are acquired from the consumption of contaminated food, water or ice. Filth flies can be important in the mechanical transmission of pathogens to food, food preparation surfaces and utensils. Fly populations sometimes reach very high levels in many areas of North Africa. *Musca sorbens* is widespread and extremely annoying. It is attracted to the eyes, nose and mouth and has a high potential for transmitting enteric pathogens.

Bacteria and viruses causing diarrheal disease include *Staphylococcus aureus*, *Clostridium perfringens*, *Bacillus cereus*, *Vibrio parahaemolyticus*, numerous serotypes of *Salmonella*, *Shigella* spp., *Campylobacter*, pathogenic strains of *Escherichia coli*, hepatitis A and E, and other viral species. Bacterial pathogens account for more than 75% of cases. Onset of symptoms is usually acute and may result in subclinical infections or severe gastroenteritis. *Shigella* infections can produce significant mortality even in hospitalized cases. The resistance of enteric pathogens to commonly used

antibiotics can complicate treatment. Years of indiscriminate antibiotic use in North Africa have selected bacterial populations with resistance to multiple antibiotics.

Bacillary dysentery has had a profound impact on military operations throughout history. Gastroenteritis was epidemic in the Mediterranean and North African theaters during World War II. The field sanitary discipline of German troops in North Africa was lax, and they suffered from excessively high rates of intestinal diseases. The Allied victory at El Alamein, Egypt, in 1942, was made possible in part by the epidemics of shigellosis that racked the German and Italian armies. Even port visits to developing countries pose significant health threats to military personnel. Twenty-one percent of the 2,747 evaluated crewmembers of the USS John F. Kennedy reported an episode of acute diarrhea after a five-day port visit to Alexandria, Egypt in 1988. Acute diarrhea requiring medical attention developed in 4% of 4,500 US military personnel on deployment in Cairo, Egypt, during July and August 1987. A survey of military personnel not requesting medical care indicated that 40% of troops had diarrhea during this deployment. Drug-resistant strains of enteropathogens were isolated from US military personnel during Operation Bright Star 96 in Alexandria, Egypt. Strict sanitation and fly control have been demonstrated to significantly reduce the risk of gastrointestinal infections.

SAND FLY-BORNE DISEASE*

The incidence and prevalence of leishmaniasis is increasing in many areas of North Africa. **Cutaneous leishmaniasis** is moderately or highly endemic in all countries except the Canary Islands. Two species of *Leishmania* cause skin lesions in the region. The less severe and rurally distributed *Leishmania major* is a parasite of desert rodents, especially gerbils (*Meriones* spp., *Gerbillus* spp., and *Psammomys* spp.). The most commonly implicated vector is the sand fly *Phlebotomus papatasi*. *Leishmania tropica* is usually a parasite of man in urban environments and is transmitted by *P. sergenti.* Man is the principal reservoir, but dogs have been found naturally infected. In recent years, outbreaks of *Le. tropica* have occurred in highland villages in the Atlas Mountains of Morocco. Multinational forces in the northeastern Sinai Desert of Egypt have experienced a high incidence of cutaneous leishmaniasis.

Visceral leishmaniasis, caused by *Le. infantum*, is a less prevalent but more severe systemic disease. It generally occurs as foci in rural areas. The most common reservoirs are believed to be domestic dogs and wild canines, such as jackals and foxes. *Phlebotomus perniciosis* is an important vector in many endemic areas of North Africa. Transmission occurs during the warmer months of April through October, coinciding with the activity of vector sand flies. Phlebotomine sand flies bite from dusk to dawn but may feed during the day if hosts enter their resting habitat. The distribution of sand flies and the diseases they carry is very focal because of their limited flight capabilities. Cutaneous manifestations of *Le. infantum* have been reported from northern areas of Algeria.

Sand fly fever is the most widespread arbovirus in North Africa and is the greatest arboviral threat to military personnel operating in the region. It caused significant

morbidity among Allied forces in the Mediterranean during World War II. Foci are distributed countrywide, but the highest risk o f transmission exists in villages and periurban areas. Local populations are generally immune as a result of childhood infection. Both the Naples and Sicilian viruses are circulating in most areas of North Africa, and the risk of infection is highest bet ween April and October, when the sand fly vector, *Phlebotomus papatasi*, is most active. Humans are the reservoir of this debilitating disease, although gerbils are suspected reservoirs.

SCHISTOSOMIASIS

Schistosoma mansoni (intestinal schistosomiasis) and *S. haematobium* (urinary schistosomiasis) are endemic throughout North Africa. **Schistosomiasis** produces serious acute and chronic morbidity and has had a significant impact on military operations in the past. It is the most important communicable disease in Egypt, where risk of transmission is high along the entire Nile River and along the Nile Delta. Distribution is focal and incidence is low in Algeria, Libya, Tunisia, and Morocco. Intestinal schistosomiasis occurs primarily in Egypt and Libya. Urina ry schistosomiasis predominates in all continental North African countries.

Infection is acquired through penetration of the skin by free -swimming larval forms of trematode parasites that develop in freshwater snails of the genus *Bulinus*, the intermediate host for *S. haematobium*, and the genus *Biomphalaria* in the case of *S. mansoni*. The snail intermediate hosts prefer slow-moving shallow water associated with rivers and their tributaries, marshes, irrigation canals, cisterns, aqueducts, and seasonally wet streambeds. Extensive irrigation projects throughout North Africa have expanded snail distribution and the risk of infection.

In Egypt, *S. mansoni* has been replacing *S. haematobium* since completion of the Aswan Dam. Humans are the reservoir host of sch istosomiasis. Untreated individuals can remain infected for many years. Cases often are not diagnosed until after returning from endemic areas. Military personnel should avoid contact with potentially contaminated water and not swim or wade in freshwate r lakes, ponds, streams, or irrigation ditches.

MOSQUITO-BORNE DISEASE*

Malaria is not a major public health problem in North Africa. A low risk of **vivax malaria** exists in parts of Libya, Algeria and Morocco. No indigenous cases of malaria have been officially reported from Libya since 1981, but transmission of *Plasmodium vivax* probably occurs at low levels in isolated oases and rural areas. Limited transmission of vivax malaria occurs in Algeria primarily in the southern areas. Moderate risk of malaria transmission occurs in Egypt, especially in the Nile Delta, and in valley and oases areas. Vivax malaria predominates except in Al Fayyum Governorate, where nearly all the **falciparum** cases of malaria occur. Tunisia and the Canary Islands are considered malaria-free, but foci of vivax malaria may still exist in Tunisia. Most urban areas in North Africa are malaria -free. Drug-resistant strains of malaria have not been reported from North Africa.

Less than a dozen species of *Anopheles* mosquitoes act as primary or secondary vectors throughout the region. Limited rainfall in vast arid and semiarid areas restricts the natural distribution of malaria vectors in North Africa. Irrigation projects for agricultural production have extended the range of malaria vectors in many countries, and disease prevalence may increase in such areas. Insecticide-resistant vector populations have resulted from decades of malaria control operations, especially in Egypt. Transmission may occur year-round in most areas, but peaks during warmer months.
Competent vectors exist in areas considered malaria-free. Imported immigrant cases have the potential of re-establishing indigenous transmission of malaria. Construction of the trans-Saharan highway from the coast of Algeria to Nigeria and Ghana has increased the risk of introducing malaria and West African vectors such as *Anopheles gambiae*. Infected foreign troops can be expected to spread malaria into malaria-free areas. Drug-resistance has not been reported from the region. Chemoprophylaxis should be strictly enforced in military personnel at risk of infection.

Rift Valley Fever (RVF), caused by a *Phlebovirus*, was restricted to sub-Saharan Africa until a 1977 epidemic in Egypt resulted in an estimated 18,000 human cases. The principal vector during the epidemic was *Culex pipiens*. RVF virus is capable of infecting a wide range of hosts, including domestic animals, and infection is frequently acquired by exposure to secretions or blood from infected animals. Another epizootic occurred in Egypt during 1993-94 and involved 4,000 human cases. The current enzootic status of RVF virus in Egypt and other countries of North Africa is unclear. *Culex pipiens* and other competent vectors are abundant throughout the region. RVF could have a serious impact on military operations and should be considered during any outbreak of febrile illness in military personnel.

There is limited potential for **dengue** transmission due to the absence of its primary mosquito vector, *Aedes aegypti*, in most areas of North Africa. Risk of transmission is highest in southeastern coastal areas of Egypt adjacent to Sudan. Dengue cases were reported from the coastal areas of Sudan in the 1980s. Serological studies and viral isolates from mosquitoes indicate that **Sindbis** and **West Nile** viruses are probably enzootic at low levels in every country of North Africa except the Canary Islands; however, they present minimal risk to military operations. Several viruses transmitted by soft ticks have been isolated from sea birds on islands and from coastal areas. Infectivity of these viruses for man and animals is unknown, but they should have little military significance. Tunis virus, a *Phlebovirus*, has been found in pigeons and *Argas* ticks in Tunisia. Additional obscure arboviruses have been isolated from several areas of North Africa. The health risks of these viruses are not well known.

Sporadic cases of mosquito-borne **Bancroftian filariasis** have been reported from the eastern Nile River Delta in Egypt. Incidence of the disease has increased in some focal areas. Transmission by the mosquito *Culex pipiens* occurs year-round but is highest in the summer and fall. Filariasis has little military significance.

LOUSE-BORNE DISEASE*

Sporadic cases of **louse-borne relapsing fever** have been reported from Egypt, Libya and Morocco, but endemic foci may exist elsewhere in the region where body louse infestations are common. **Epidemic typhus**, also transmitted by body lice, is rare but has occurred in rural villages of Egypt and western areas of Libya, including Tripoli. Nomads in the region are the most likely reservoir for typhus. Both diseases proliferate under crowded and unsanitary conditions resulting from the social upheaval of war or natural disasters.

TICK-BORNE DISEASE*

Tick-borne relapsing fever, transmitted from rodent reservoirs to humans by soft ticks is enzootic in many rural areas. Vector ticks commonly infest caves, bunkers and tombs. Sporadic human infections are reported from all North African co untries. **Boutonneuse fever** (also termed African tick typhus), transmitted by the brown dog tick, *Rhipicephalus sanguineus*, and other ixodid ticks, is also distributed throughout the region. The risk of infection is elevated in cities and villages with hi gh populations of dogs. **Q fever** is an acute febrile rickettsial disease contracted primarily by inhalation of airborne pathogens or contact with secretions of infected domestic animals. Serological surveys indicate that Q fever is highly endemic througho ut North Africa. Troops should avoid contact with domestic animals. Evidence of **Lyme disease,** vectored by *Ixodes* ticks, principally *I. ricinus*, has been reported from Tunisia and the Canary Islands. Its public health significance in North Africa is unkn own, but it may be an emerging zoonotic disease.

Crimean-Congo hemorrhagic fever is the most prevalent tick -borne virus in North Africa. It infects domestic animals in every country in the region except the Canary Islands and is widely distributed in di screte foci in agricultural and semi -desert areas. Sporadic human cases occur. The disease can be contracted by the bite of infected *Hyalomma* ticks, but most human cases result from exposure to secretions or blood from infected animals or humans. This i s militarily significant, since troops had frequent exposure to camels, goats and other domestic animals during the Persian Gulf War and would have similar high levels of exposure to domestic animals during military operations in North Africa. Medical wor kers treating patients are at high risk of becoming infected. Clinical symptoms can be severe, with mortality rates of up to 50%. Military personnel should avoid exposure to sheep, goats, cattle and other domestic animals and should not sleep or rest in animal shelters.

FLEA-BORNE DISEASE*

Murine typhus is a rickettsial disease similar to louse -borne typhus but milder. It is enzootic throughout the region in domestic rats and mice and possibly other small mammals. Infected rat fleas (usually *Xenopsylla cheopis*) defecate infective rickettsiae while sucking blood. Airborne infections can occur. Sporadic human cases have been reported throughout North Africa. Cases in US military personnel occurred during Operation Restore Hope in Somalia. Enzootic **plague** foci are poorly known. Human cases are rare and were reported most recently from the northeastern Libyan coast. Plague outbreaks have historically occurred in urban areas and port cities of Egypt.

Plague should have little impact on military operat ions in North Africa. Military personnel should never handle wild or domestic rodents, especially if these animals show signs of illness.

RODENT-BORNE DISEASE
Field rodents are reservoirs for several closely related viruses that can be transmitted to humans when exposed to airborne pathogens from dried rodent excreta. The epidemiological status of hantaviral disease in North Africa is not known. Serological evidence of **hantaviral** infection has been detected in humans and wild animals in Algeria and Egypt, and these viruses may be circulating in other countries of the region. Hantaviral diseases are an emerging public and military health threat. **Leptospirosis** should be considered enzootic in most countries of North Africa. The spirochete is transmitted when skin or mucous membranes are contacted by water contaminated with urine of infected domestic and wild animals, especially rats. Military personnel would be at high risk of infection from this disease. Troops should never handle rodents and should not sleep or rest near rodent burrows.

CONJUNCTIVITIS
Bacterial and viral **conjunctivitis** and **trachoma,** caused by the bacterium *Chlamydia trachomatis*, are widespread in North Africa and have epidemic potential. Transmission is normally through contact with secretions of infected persons or contaminated articles. Eye gnats and flies can mechanically transmit pathogens, especially the face fly, *Musca sorbens*. The high levels of airborne sand and dust common in arid environments aggravate conjunctivitis.

VENOMOUS ANIMALS
Fifteen species of venomous terrestrial **snakes** are regionally distributed in diverse habitats. Military personnel should be thoroughly briefed on the risk and prevention of snakebite, as well as the steps to take immediately after snakebite . Effective antivenoms are available. North Africa is also inhabited by some of the world's most venomous **scorpions**. However, scorpion stings rarely require hospitalization. Troops should be warned not to tease or play with snakes and scorpions.

*** A properly worn Battle Dress Uniform (BDU) impregnated with permethrin, combined with use of extended duration DEET on exposed skin, has been demonstrated to provide nearly 100% protection against most blood-sucking arthropods. This dual use of highly effective repellents on the skin and clothing is termed the "DoD arthropod repellent system." It is the most important single method of protecting individuals against arthropod-borne diseases. Permethrin can also be applied to bednets, tents and screens to help prevent disease transmission by insects. The proper use of repellents is discussed in TIM 36, Personal Protective Techniques Against Insects and Other Arthropods of Military Significance.**

VECTOR-BORNE DISEASES IN NORTH AFRICA (+ = present; ? = uncertain)

	Canary Islands	Algeria	Egypt	Libya	Morocco	Tunisia
falciparum malaria			+			
vivax malaria		+	+	?	+	?
sand fly fever		+	+	+	+	+
dengue			?			
epidemic typhus			+	+		
louse-borne relapsing fever		?	+	+	+	?
tick-borne relapsing fever		+	+	+	+	?
Crimean-Congo hemorrhagic fever		+	+	+	+	+
boutonneuse fever		+	+	+	+	+
Q fever	+	+	+	+	+	+
murine typhus		+	+	+	+	+
plague		?	?	+		
Rift Valley fever			?	?		
West Nile virus		?	+	+	+	+
Sindbis virus		?	+	+	?	?
cutaneous leishmaniasis		+	+	+	+	+
visceral leishmaniasis		+	+	+	+	+
urinary schistosomiasis	?	+	+	+	+	+
intestinal schistosomiasis			+	+		
Bancroftian filariasis			+			
Lyme disease	+		+			+
leptospirosis	+	+	+	?	?	?
hantaviral diseases		+	+	?	?	?

Africa


North Atlantic Ocean
South Atlantic Ocean
Indian Ocean
Arabian Sea
Mediterranean Sea
Black Sea
RUSSIA
KAZAKHSTAN
UKRAINE
POLAND
BELARUS
GERMANY
FRANCE
SPAIN
PORTUGAL
ITALY
GREECE
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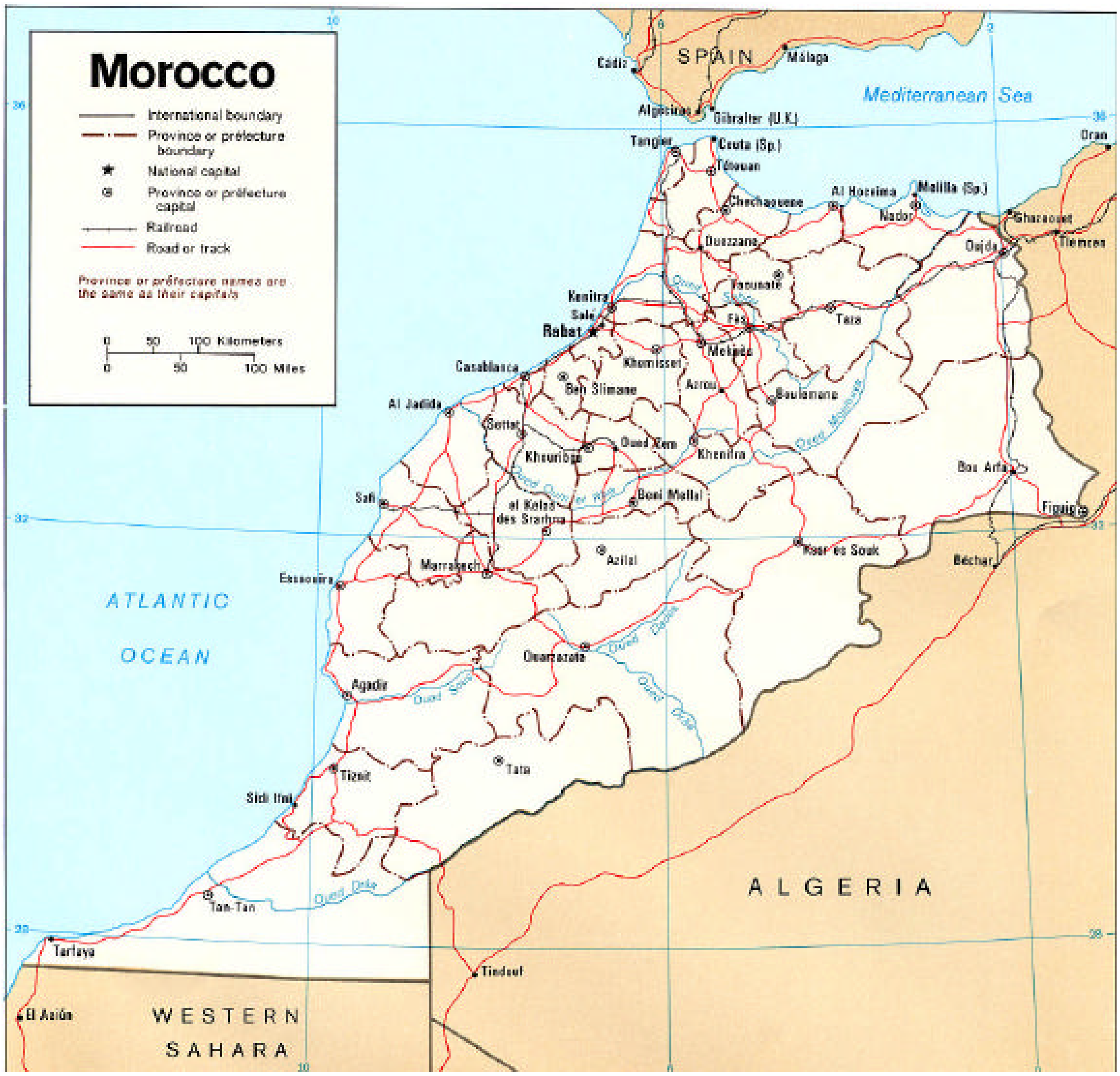
OMAN
YEMEN
MOROCCO
ALGERIA
TUNISIA
LIBYA
EGYPT
Western Sahara
MAURITANIA
MALI
NIGER
CHAD
SUDAN
ERITREA
DJIBOUTI
ETHIOPIA
SOMALIA
CAPE VERDE
SENEGAL
THE GAMBIA
GUINEA-BISSAU
GUINEA
SIERRA LEONE
LIBERIA
CÔTE D'IVOIRE
GHANA
TOGO
BENIN
BURKINA FASO
NIGERIA
CAMEROON
CENTRAL AFRICAN REPUBLIC
EQUATORIAL GUINEA
GABON
REP. OF THE CONGO
DEM. REP. OF THE CONGO
UGANDA
KENYA
RWANDA
BURUNDI
TANZANIA
ANGOLA
ZAMBIA
MALAWI
MOZAMBIQUE
ZIMBABWE
NAMIBIA
BOTSWANA
SOUTH AFRICA
LESOTHO
SWAZILAND
MADAGASCAR
SEYCHELLES
Scale 1:51,400,000
Azimuthal Equal-Area Projection
800 Kilometers
800 Miles
Boundary representation is not necessarily authoritative.


Algeria
International boundary
Département boundary
National capital
Département capital
Standard-gauge railroad
Narrow-gauge railroad
Road
Départements have the same name as their administrative center.
0 100 200 300 Kilometers
0 100 200 300 Miles
Lisbon
PORTUGAL
SPAIN
BALEARIC ISLANDS (Sp.)
Sardinia (It.)
Sicily (It.)
Mediterranean Sea
GIBRALTAR (U.K.)
ATLANTIC OCEAN
Rabat
Casablanca
Fès
Safi
Marrakech
MOROCCO
Oujda
Alger
Tizi Ouzou
Bejaia
Jijel
Skikda
Annaba
Bizerte
Tunis
Blida
Médéa
Sétif
Batna
Oum el Bouaghi
Tebessa
Mostaganem
El Asnam
Oran
Sidi Bel Abbès
Tlemcen
Saïda
Tiaret
M'Sila
Biskra
Djelfa
Laghouat
Sfax
Gabès
Tripoli
TUNISIA
El-Oued
Touggourt
Ouargla
Béchar
LIBYA
Ohanet
In Amenas
Tindouf
Adrar
WESTERN SAHARA
MAURITANIA
Tamanrasset
In Guezzam (well)
MALI
NIGER

Canary Islands


Egypt
International boundary
National capital
Railroad
Expressway
Road
0 50 100 150 Kilometers
0 50 100 150 Miles
Lambert Conformal Conic Projection, SP 24N/29N
Crete (GR.)
Nicosia
CYPRUS
Famagusta
UN buffer zone
Larnaca
Paphos
Limassol
Tarţūs
Ḩimş
Tripoli
LEBANON
Beirut
SYRIA
Damascus
UNDOF Zone
GOLAN HEIGHTS*
Haifa
ISRAEL
WEST BANK*
Irbid
Tel Aviv-Yafo
Jerusalem
'Amman
1949 Armistice Line
1950 Truce Line
Dead Sea
JORDAN
GAZA STRIP*
Beersheba
Mediterranean Sea
Bardiyah
As Sallūm
Marsā Maţrūḩ
LIBYA
Al Jaghbūb
Sīwah
Alexandria
Baltīm
Damietta
Port Said
Kafr ash Shaykh
Damanhūr
Ţanţā
Al Manşūrah
Az Zaqāzīq
Shibīn al Kawm
Banhā
Suez Canal
Ismailia
Al 'Arīsh
Cairo
Al Jīzah
Ḩulwān
Suez
Sinai
Birkat Qārūn
Al Fayyūm
Banī Suwayf
Ra's Sudr
Elat
Al 'Aqabah
Ḩaql
Al Bi'r
Tabūk
Gulf of Suez
Gulf of Aqaba
Al Bawīţī
Al Minyā
Ra's Ghārib
Aţ Ţūr
Sharm ash Shaykh
SAUDI ARABIA
Dubā
Al Ghardaqah
Asyūţ
Nile
Būr Safājah
Sūhāj
Qinā
Al Quşayr
Al Wajh
Luxor
Mūţ
Al Khārijah
Red Sea
Marsā al 'Alam
Idfū
Bārīs
Aswan High Dam
Aswān
Baranīs
Lake Nasser
Administrative Boundary
Abū Sunbul
Ḩalā'ib
Lake Nubia
Wādī Ḩalfā
SUDAN
Dunqunāb
*The Golan Heights is Israeli-occupied Syria; the West Bank and Gaza Strip are Israeli occupied with current status subject to the Israeli-Palestinian Interim Agreement—permanent status to be determined through further negotiation.
Boundary representation is not necessarily authoritative.

Libya
International boundary
Baladīyat boundary
National capital
Baladīyat capital
Railroad
Road
Track
Baladīyah (municipalities)
1. AN NUQAT AL KHAMS
2. AZ ZĀWIYAH
3. AL 'AZĪZĪYAH
4. TARĀBULUS
5. AL KHUMS
6. TARHŪNAH
7. ZLĪTAN
8. MIŞRĀTAH
9. AL JABAL AL AKHḐAR
Mediterranean Sea
Ionian Sea
Gulf of Sidra
TUNISIA
ALGERIA
EGYPT
NIGER
CHAD
SUDAN
GREECE
MALTA
Valletta
Tripoli
Tunis
Sicily
Crete
Banghāzī
Surt
Sabhā
GHADĀMIS
GHARYĀN
SAWFAJJIN
SURT
AJDĀBIYĀ
ṬUBRUQ
AL JUFRAH
ASH SHĀṬI'
AWBĀRI
MURZŪQ
AL KUFRAH


Morocco
International boundary
Province or préfecture boundary
National capital
Province or préfecture capital
Railroad
Road or track
Province or préfecture names are the same as their capitals
0 50 100 Kilometers
0 50 100 Miles
SPAIN
Cádiz
Málaga
Algeciras
Gibraltar (U.K.)
Mediterranean Sea
Oran
Tangier
Ceuta (Sp.)
Tétouan
Chechaouene
Al Hoceima
Melilla (Sp.)
Nador
Ghazaouet
Tlemcen
Ouezzane
Oujda
Kenitra
Taounate
Sale
Rabat
Fès
Taza
Meknès
Khemisset
Casablanca
Ben Slimane
Azrou
Boulemane
Al Jadida
Settat
Oued Zem
Khenifra
Khouribga
Bou Arfa
Safi
el Kelaa des Srarhna
Beni Mellal
Figuig
Azilal
Ksar es Souk
Béchar
Essaouira
Marrakech
ATLANTIC
OCEAN
Ouarzazate
Oued Dadès
Agadir
Oued Souss
Oued Drâa
Tiznit
Tata
Sidi Ifni
Tan-Tan
ALGERIA
Tarfaya
Tindouf
El Aaiún
WESTERN
SAHARA


Tunisia
International boundary
Governorate boundary
National capital
Governorate capital
Railroad
Road
Governorates have the same names as their capitals.
0 50 100 Kilometers
0 50 100 Miles
Mediterranean Sea
ALGERIA
LIBYA
ITALY
Sicily
Strait of Sicily
Gulf of Tunis
Golfe de Hammamet
Gulf of Gabes
Tunis
Bizerte
Tabarka
Béja
Jendouba
Le Kef
Siliana
Zaghouan
Nabeul
Sousse
Monastir
Moknine
Mahdia
Kairouan
Thala
Kasserine
Sidi Bou Zid
Sfax
Mahares
Gafsa
Skhira
Gabes
Tozeur
Nefta
Kebili
El Hamma
Matmata
Medenine
Zarzis
Houmt Souk
Tataouine
Remada
Dehibat
El Borma
Tripoli
Annaba
Constantine
Tebessa
Biskra
El Oued
Touggourt
Ghadāmis
Pantelleria (ITALY)
ILES KERKENNAH
Mediterranean Sea

IV. Country Profiles.

A. Algeria.

a. Geography. Algeria is Africa's second largest country. It is about three and one-half times the size of Texas, with a total land area of about 2,381,740 sq km. Algeria consists of four geographic regions. (1) The Tell Region, along the Mediterranean Sea, consists of a 130- to 320-km wide, discontinuous coastal plain and the rugged, geologically unstable Tell Atlas Mountains (500 to 2,500 m above sea level). (2) South of the Tell Region is the High Plateau, a large steppe-like plain covered by alluvial debris, generally ranging in elevation from 400 to 1,300 m. During rainy periods, extensive shallow lakes form, which give way to saline mud flats and swamps as they evaporate or are absorbed. Chott Melrhir, the lowest spot in Algeria at 40 m below sea level, is located in the northeastern part of this region. (3) South of the High Plateau are the Sahara Atlas Mountains, which rise to more than 2,300 m. (4) The Algerian Sahara Desert, which borders the Sahara Atlas Mountains and covers more than 85% of Algeria's land area, is one of the hottest and most arid areas on earth. Sand dunes occupy about one-fourth of the Sahara. Much of the rest is covered by rocky platforms known as "hamada." The southern Sahara contains sandstone plateaus, the Ahaggar Mountains, and Algeria's highest peak, Mount Tahat (2,918 m). Land use includes 3% arable land, 13% permanent pasture, and 2% forest and woodlands.

b. Climate. Algeria's climate varies by geographic region. (1) The climate of the coastal plain and Tell Region is Mediterranean, with hot, dry summers (April to November) and mild, wet winters (December to March). Daily temperature extremes reach 44°C in summer and -1°C in winter. Snow occurs at higher elevations. Throughout this region, annual rainfall generally increases from west (380 mm) to east (660 mm), occasionally reaching 1,000 mm in the east. (2) In the High Plateau a continental climate produces mean daily maximum and minimum temperatures of 33 °C and 3°C in summer, and 14°C and 1°C in winter. Annual rainfall is less than 400 mm. (3) The Sahara's desert climate produces mean daily maximum and minimum temperatures of 45 °C and 14°C in summer, and 31°C and 10°C in winter. Mean annual rainfall is less than 200 mm. In summer, Algeria is subject to the hot, dust- and sand-laden winds (sirocco) that parch the High Plateau and coastal plain.

Algiers (elevation 60 m)

Mean Daily Temperatures (°C)

MONTH	J	F	M	A	M	J	J	A	S	O	N	D
Maximum	15	16	17	20	23	26	28	29	27	23	19	16
Minimum	9	9	11	13	15	18	21	22	21	17	13	11
Mean Monthly Precipitation (mm)												
	112	84	74	41	46	15	0	5	41	79	130	137

c. Population and Culture. Algeria's population is rapidly growing and urbanizing. It has a national population growth rate of almost 3% and an urban growth rate of about 5% per year. The national population density of 11 persons per sq km is misleading. Nearly 90% of the population is concentrated in the arable regions of the coastal plain, which has a population density exceeding 43 persons per sq km. The population consists of 99% Arab-Berbers and <1% Europeans. About 99% are Sunni Muslims (official state religion) and 1% are Christians or Jews. Total population 30.5 million, 50% urbanized, literacy rate 62%.

d. Water, Living and Sanitary Conditions. Except along the Mediterranean coast, water generally is scarce and droughts are common. Water sources include aquifers, springs, wells, rain catchments, and rivers. Except for the Chelif River in the Tell Atlas Mountains, rivers are seasonal. Throughout most of Algeria, except for some deep artesian wells, ground water is saline or brackish due to dissolved minerals. Municipal water and treatment systems are rare, and many are inoperable or antiquated, poorly maintained and intermittently operated. Few houses have individual hookups. Drinking water distribution is mostly through standpipes. Industrial waste and petrochemicals pollute many surface water sources, especially along the Mediterranean coast.

Algeria has widespread sanitation problems, and living conditions are generally poor by Western standards. Few urban homes have septic or water systems, municipal sewage systems are limited to large urban areas and, except for Algiers, serve only parts of the community. Rural people indiscriminately dispose of excreta or use it as fertilizer. Garbage and trash collections, limited to larger cities, often are dumped at the edge of town, attracting and supporting large populations of rodents and filth flies. Associated incidence and risk of transmission of several important vector-borne diseases are high. Critical housing shortages in urban areas have led to poor quality construction and frequently overcrowded conditions, with as many as eight persons per room. Rural housing consists of huts made of mud and branches, where space may be shared with domestic animals. Nomadic Bedouins live in tents made of animal skins and woven cloth, or huts constructed of grass over a wooden frame. Throughout most of Algeria, poor food, inadequate sanitation, contaminated water supplies, and extreme desert heat present significant health risks. Population growth and urbanization are making these conditions worse.

B. Canary Islands.

a. Geography. The Canary Islands form an archipelago of seven main islands, located about 100 km west of the coast of Morocco at about 28° N latitude and 13° to18° W longitude. They include about 7,500 sq km of land area, nearly 2.5 times the size of Rhode Island. These islands constitute two of Spain's provinces. They are rugged and volcanic, with the highest peak, a volcanic crater called Canadas (or Pico) del Teide, on the island of Tenerife, reaching 3,718 m. This peak is snow-capped all year.

b. Climate. Summer temperatures are rarely high due to the influence of the cold waters of the Canaries Current. The hottest summer days occur when hot, dry air drawn from the Sahara Desert reaches these islands. This air may sometimes also carry much fine dust from the desert. The air's temperature drops and acquires moisture as it passes

over the ocean, making its impact less extreme. Winters are mild. Occasionally an Atlantic depression may cause turbulent weather, but stormy, wet periods are infrequent. Fog or clouds may occur in summer months, which are usually sunny and dry, with very few hot days. The islands' northern shores are more exposed to the predominantly northeast trade winds, and are usually wet year round. Sunshine typically ranges from 6 hrs per day in winter to 10 or 11 hrs per day in summer.

Las Palmas, Gran Canaria (elevation 6 m)

Mean Daily Temperatures (^oC)

MONTH	J	F	M	A	M	J	J	A	S	O	N	D
Maximum	21	22	22	22	23	24	25	26	26	26	24	22
Minimum	14	14	15	16	17	18	19	21	21	19	18	16

Mean Monthly Precipitation (mm)

	J	F	M	A	M	J	J	A	S	O	N	D
	36	23	23	13	5	0	0	0	56	28	53	41

c. Population and Culture. The people, often called Canarios, are currently considered indigenous to the Canary Islands. They are a mixture of Spanish, pre-Spanish native Guanches, and numerous other immigrant races. About 99% of the population is Christian (Catholicism is the official state religion). One percent is other religions. Population density is about 200 persons per sq km. The main industry is tourism and the main language is Spanish. Total population 1.5 million, literacy rate 96%.

d. Water, Living and Sanitary Conditions. Municipal water and sewage treatment are available to most homes, hotels, and commercial buildings in cities on all of the seven largest islands. However, the smaller islands, upland areas of the main islands, and many agricultural areas still have only limited access to such services. The mild climate and ready access to the ocean make living conditions pleasant. Tourism and associated transportation and trade have developed and help maintain a fairly high standard of living for most of the people. Most Canarios still eat rather simple foods such as fish, locally grown vegetables, potatoes, and a kneaded grain bread. Since sanitation is fairly good throughout most of the islands, the risks of food and water-borne disease are minimal, especially in urban areas.

C. Egypt.

a. Geography. Egypt, with a total land area of about 997,450 sq km, is about three times the size of New Mexico and can be geographically divided into four regions. (1) The Western Desert, less than 300 m above sea level, constitutes 68% of Egypt's land area. It is an arid region of salt marshes and vast, rolling, shifting sand dunes broken up by large depressions, with the Mediterranean Sea lying on its north coast. Egypt's lowest point, the Qattara Depression (133 m below sea level), is in this region. (2) The Eastern Desert, also known as the Arabian Desert, is an elevated plateau broken by deep valleys. It is bounded on the north by the Mediterranean Sea and on the east by the Gulf

of Suez and the Red Sea and by Sudan on the south. This region contains highlands, with peaks up to 2,100 m. (3) The Nile Valley and Delta separate the Eastern and Western Deserts. Africa's longest river and Egypt's lifeline, the Nile River, along with manmade Lake Nasser, created by the Aswan High Dam, dominate Egypt's geography. (4) The Sinai Peninsula, east of the Eastern Desert, is bounded by the Gulf of Suez on the west and the Gulf of Aqaba and Israel on the east. The Sinai Peninsula comprises the low-lying sandy plain of the Sinai Desert on the north, and a plateau with broken highlands rising to the south, including Mount Catherine, Egypt's highest point at 2,629 m. Only 2% of Egypt's land area is arable.

b. Climate. Egypt's arid climate, marked by intense sunlight and a severe shortage of rainfall, varies by region and season. The mean daily maximum Mediterranean coastal temperature during summer (May to October) is 30 ^{o}C, occasionally reaching a high of 42^{o}C. Winter (November to April) produces mean daily temperatures varying from 10 ^{o}C to 24^{o}C, occasionally dropping to a low of 1 ^{o}C. The mean daily maximum coastal temperature along the Gulf of Suez in summer is 34 ^{o}C, occasionally reaching a high of 48^{o}C. Winter mean daily temperatures vary from 14^{o}C to 28^{o}C, occasionally dropping to a low of 4^{o}C. Desert summer temperature extremes reach 49 ^{o}C and can drop to 3^{o}C. Winter produces mean daily maximum and minimum temperatures of 33 ^{o}C and 1^{o}C with occasional frost and snow. Temperatures in the desert may vary as much as 30 ^{o}C in a 24-hr period. Interior desert areas may receive rain once in several years. During summer, the khamsin winds, or sandstorms, sometime last several days, with wind speeds exceeding 145 km/h. These winds are capable of raising temperatures by 20^{o}C in less than 2 hours. Prevailing northerly winds temper Egypt's Mediterranean coastal climate and deliver most of its rainfall. Northern coastal areas receive a scant 200 mm of rainfall annually, while southern Egypt receives 80 mm or less, and the Sinai receives about 120 mm.

Cairo (elevation 74 m)

Mean Daily Temperatures (^{o}C)

MONTH	J	F	M	A	M	J	J	A	S	O	N	D
Maximum	18	21	24	28	33	35	36	35	32	30	26	20
Minimum	8	9	11	14	17	20	21	22	20	18	14	10

Mean Monthly Precipitation (mm)

	J	F	M	A	M	J	J	A	S	O	N	D
	5	5	5	3	3	0	0	0	0	0	3	5

c. Population and Culture. Egypt's population is mostly poor and nearly half are illiterate. About 99% of the people live along the Nile River on only 4% of the land. Although overall population density is about 54 persons per sq km, densities vary from more than 30,000 per sq km in Cairo to less than 1 person per sq km in some of the Frontier Governorates. The ethnic make-up of the population is 99% Eastern Hamitic. The religious make-up is 94% Muslim (mostly Sunni), 6% other. Overcrowding, a major problem in cities, strains the country's infrastructure. The disparity between national resources and Egypt's growing population (2% growth per year) is a major obstacle to the

government's drive to raise living standards. The Aswan High Dam, completed in 1971, provided irrigation water for more than 405,000 additional hectares (ha) of land but altered the ancient cycle of annual flooding of croplands. The creation of Lake Nasser has provided an inland fishing industry and water for intensive irrigation. This has resulted in significant sociological changes. Agricultural workers now spend more days in irrigated fields. More people can use electric-powered equipment, and most of the population has much greater access to potable water. Total population 66 million, 44% urbanized, literacy rate 51%.

d. Water, Living and Sanitary Conditions. The construction of the Aswan High Dam and drilling of deep artesian wells in the Western Desert have greatly increased the amount of water available for irrigation. This has led to year-round irrigation and higher soil water levels. Reduced flow velocity of water in surface canals has caused severe water pollution and provided excellent breeding conditions for vector snails that support *Schistosoma mansoni* as well as for other disease vectors in many parts of the country. Diseases that are increasing include trachoma, lymphatic filariasis, *S. mansoni*, and fascioliasis. Increased availability of potable water throughout Egypt has not been accompanied by adequate waste and wastewater removal and treatment systems, with the result that breeding sites for a variety of vermin and vectors have proliferated. Egypt's standard of living is poor compared to its Arab neighbors. Urban sewage disposal is at a crisis stage. About 70% of the urban population and only 16% of the rural population have access to municipal sewage facilities. The remaining sewage flows into canals that sometimes are used as sources of water for drinking and other domestic needs. Sewers frequently clog, causing city streets to flood. Cairo treats only about 50% of the sewage discharged from its systems. Refuse collection and disposal are inadequate throughout Egypt, contributing to rodent and insect populations. Thirty to 50% of Cairo's waste is dumped in streets, vacant areas, or canals. Collected waste is taken outside the city limits, where it is burned, scavenged or allowed to accumulate. Many people depend on scavenging refuse piles to survive. Compounding this problem are the hazardous wastes from industry and hospitals that are often mixed with refuse. Housing is limited and substandard. Construction materials consist mainly of concrete and wood, mudbrick, or straw soaked with mud. New construction projects have been shown to increase populations of sand flies and the risk of disease transmission. In Cairo, more than 3 million squatters (45% of the city's population) live in squalid suburbs. Many inhabit graveyards because these areas provide the only available living space reasonably close to food and water. Livestock commonly share shelters with their owners. These conditions foster the breeding of vectors and transmission of diseases.

D. Libya.

a. Geography. Libya is the fourth largest country in Africa (slightly larger than Alaska). It has a total land area of approximately 1,759,540 sq km and can be divided into three geographic regions. (1) Tripolitania (Western Provinces), encompassing the northwestern quadrant, has a narrow coastal strip interspersed with oases and lagoons. Immediately inland from the coastal strip, the Jefara Plain rises southward to the Jabal

Nafusah Plateau, with elevations between 600 and 900 m. Farther south is the Hamada el-Homra, a rocky, barren plateau with numerous depressions. (2) Cyrenaica (Eastern Provinces), encompassing the eastern one-half of Libya, has a rugged coastline, followed inland by the al-Marj Plain, which rises abruptly to form the Green Mountain Plateau (Jabal al Akhdar); the maximum elevation is approximately 600 m. The western side of Jabal al Akhdar falls steeply to the Gulf of Sidra, while the eastern side, known as Marmarica, falls gradually in a series of ridges. This area includes Libya's lowest point, Sabkhat Ghuzayyil, which is 47 m below sea level. To the south is desert, with sand dunes reaching elevations of 100 m. (3) The Fezzan region (Southern Provinces) of southern Libya consists of the Sahara Desert, with scattered oases and depressions, and the Tibesti, a zone of hills and mountains in the far south rising to Libya's highest point, Bikku Bitti at 2,267 m. Only 1% of Libya's land is arable; about 4,700 sq km is irrigated, and about 8% is suitable for use as pastureland.

b. Climate. Libya has four major climatic zones. (1) The coast has hot, humid summers (May to September) and mild winters (December to February). Summer and winter extreme highs and lows are 48 °C and 8°C, and 34°C and 0°C, respectively. Mean annual rainfall is about 300 mm, most of which falls from November through February as torrential downpours. (2) Plateau and highland areas at 600 m have summer temperatures similar to the coast. Winter mean daily maximum and minimum temperatures are 25 °C and 5°C. Winter extreme highs and lows are 39°C and -3°C. Mean annual rainfall is approximately 500 mm. (3) Higher elevations are cooler, with occasional frost, sleet, and snow in winter. (4) The Sahara Desert region is hot and dry, with extreme diurnal temperature changes. Summer temperatures are approximately 3 to 6 °C warmer than the coast. Winter mean daily maximum and minimum temperatures are 33 °C and 5°C. Winter extreme highs and lows are 44 °C and -3°C. Rainfall is irregular and infrequent; mean annual precipitation is less than 200 mm. Hot, dry, dust-laden winds are an environmental hazard and exacerbate eye infections.

Tripoli (elevation 81 m)

Mean Daily Temperatures (°C)

MONTH	**J**	**F**	**M**	**A**	**M**	**J**	**J**	**A**	**S**	**O**	**N**	**D**
Maximum	16	17	19	22	24	27	29	30	29	27	23	18
Minimum	8	9	11	14	16	19	22	22	22	18	14	9

Mean Monthly Precipitation (mm)

	J	F	M	A	M	J	J	A	S	O	N	D
	81	46	28	10	5	3	0	0	10	41	66	94

c. Population and Culture. Libya's mostly urban population is concentrated in the northern Cyrenaica (Eastern Provinces) and northern Tripolitania (Western Provinces) regions. Overall population density is 3.2 persons per sq km, but approximately 90% of the population lives on 10% of the land, and 75% of the population lives in urban areas within 10 km of the Mediterranean Sea. Most of the remainder of the population lives near oases in the dry upland areas. The population growth rate is nearly 4% per year.

Further urbanization will continue to deteriorate urban life and promote the emergence of more and larger shantytowns. Religious make-up of the population is 97% Sunni Muslim, 3% other. Its ethnic make-up is 97% Berber and Arab, and 3% other. Total population 5.7 million, literacy rate 76%.

d. Water, Living and Sanitary Conditions. The majority of urban residents have access to sand-filtered and chlorinated water. However, breaks in distribution lines and cross connections are persistent problems that result in contaminated tap water. Petrochemicals and industrial wastes have contributed to pollution of surface waters in much of the northern coastal zone. Rural residents obtain water from oases. Modern water treatment facilities were built near Birak in 1977, and this quickly led to significant reduction of several water-related diseases and parasites. However, as equipment broke down, treatment supplies ran out, and trained personnel were no longer available to properly operate, maintain or repair treatment or distribution equipment, several diseases returned to high levels. This resurgence occurred less than three years after construction of the treatment facilities. Since the United Nations Security Council's imposition of sanctions on Libya in 1992, living conditions and investment in infrastructure have steadily declined. Generally, living and sanitary conditions, including food sanitation, are inadequate by Western standards, though most of the population has access to some sanitary facilities. In urban areas, wealthier residents have direct hookups to municipal water and sewage systems. Modern apartments with electricity, running water, and sanitary facilities are common in northern cities. Low-income inhabitants, mostly foreign laborers or previously nomadic tribesmen, inhabit overcrowded dwellings on the periphery of some cities. These areas lack municipal sanitation services; refuse is sporadically collected and accumulates in the streets.

E. Morocco.

a. Geography. Morocco is slightly larger than California, with a total land area of about 446,300 sq km. It can be divided into three geographic regions. (1) Fertile lowlands extend from the Atlantic coast to the Atlas Mountains and occupy more than one-fifth of the total land area. (2) The Atlas Mountains, comprising four distinct mountain chains, cover more than one-third of the total land area. The Anti-Atlas, Haut or High Atlas, and Moyen or Middle Atlas extend in parallel fashion along Morocco's northeast-southwest axis, with the Rif Atlas extending parallel to the Mediterranean coast. Peak elevations range from1,800 m in the Rif Atlas to over 4,000 m in the Haut Atlas, which includes Jebel Toubkal, the highest point in Morocco at 4,165 m. The Rif Atlas Mountains are geologically unstable and subject to earthquakes. The lowest point in the country is Sebkha Tah at -55 m. (3) South of the Atlas Mountains lies a rocky, narrow, irregular plateau, which is a northern extension of the Sahara Desert. Land use is diverse, with 21% arable, 1% in permanent crops, 47% in permanent pasture (mainly in the mountain foothills), and 20% forested. About 112,600 sq km of land are irrigated.

b. Climate. Morocco has two climatic zones, divided by the Haut Atlas. Northern and central Morocco have a Mediterranean climate with warm, wet winters (December to February) and hot, dry summers (June to August). Spring and fall are transitional periods. Cooled by offshore winds, mean daily maximum and minimum temperatures for coastal regions in summer are approximately 27 ^{o}C and 17^{o}C but temperatures are

sometimes as high as 48°C. In winter, the mean daily maximum and minimum temperatures are 19°C and 8°C. Temperatures are about 6°C lower in the mountains, where wide diurnal variation occurs throughout the year. South of the Atlas Mountains, a semiarid desert climate predominates, with summer sirocco winds blowing in from the Sahara. Precipitation varies throughout Morocco, becoming less as one moves south and east. The rainy season is November to March, with a mean annual precipitation along the coast and in the mountains of approximately 1,000 mm; the desert region south of the Atlas Mountains receives only about 100 mm annually. During winter, snow covers the western flanks of the mountains and the peaks of the Haut Atlas.

Rabat (elevation 65 m)

Mean Daily Temperatures (°C)

MONTH	J	F	M	A	M	J	J	A	S	O	N	D
Maximum	17	18	20	22	23	26	28	28	27	25	21	18
Minimum	8	8	9	11	13	16	17	18	17	14	12	9

Mean Monthly Precipitation (mm)

	J	F	M	A	M	J	J	A	S	O	N	D
	66	64	66	43	28	8	0	0	10	48	84	86

c. Population and Culture. Although Morocco's overall population density is about 36 inhabitants per sq km, most of the population lives in the Atlantic lowlands and in the foothills of the Atlas Mountains. Casablanca and its environs, with approximately 2,000 persons per sq km, is the most densely populated area. The high population growth rate (1.9% nationally and 3.6% in urban areas) stresses already overcrowded urban areas, adversely affecting the public health infrastructure. The population's ethnic make-up is 99% Arab and Berber, 1% other. Religious make-up is 99% Muslim (mainly Sunni), 1% other. The official language is Arabic, but French and several Berber dialects are frequently spoken. Total population 29.1 million, 47% urbanized, literacy rate 44%.

d. Water, Living and Sanitary Conditions. Morocco's water sources include rivers, underground springs, wells, and rain catchments. On the coastal plains, from the Atlas Mountains north, water resources generally are sufficient except during summer. Water from wells is often brackish. Throughout larger urban areas, municipal water treatment systems filter and chlorinate water before distribution. However, contamination during distribution occurs due to inadequate supplies, broken water lines, unreliable treatment capability, and lack of trained personnel. This leads to significant disease transmission. Water shortages and low pressure are frequent problems, especially from April through October. Only 70% of the urban population has access to piped water; distribution is mostly through standpipes, though some houses have individual hookups. Rural residents obtain water directly from raw water sources. Overall, living and sanitary conditions in Morocco are poor. Sewage treatment facilities are in various stages of planning or development in the cities of Agadir, Fez, Marrakech, Meknes, Oujda, Safi, and Tetouan. Casablanca has a single sewage pretreatment facility where effluent is screened to remove large particles, then stands to remove sediment, and finally is pumped directly into the ocean. Most rural inhabitants dispose of excreta indiscriminately or use

it as fertilizer. Some large cities and urban areas have regular garbage and trash collection, but hazardous materials such as medical waste are not removed. Dumps generally are unregulated and not sealed to prevent leaching of contaminants into the ground water. Uncontrolled urban migration has resulted in housing shortages in most urban areas. Construction of urban housing varies from a few modern apartment buildings and private residences to shacks built of flattened oil drums. Nationwide, approximately half of the urban population lives in shantytowns (known as bidonvilles), which surround most cities. Rural housing often is overcrowded and consists of huts made of mud with thatched roofs, where residents often share space with domestic animals. These conditions are ideal for breeding of vermin and vectors, and for the spread of a wide variety of diseases and parasites of military importance.

F. Tunisia.

a. Geography. Tunisia is North Africa's smallest country, but it is strategically located near the middle of the Mediterranean Sea. With a total land area of 155,360 sq km, it is slightly larger than the state of Georgia and can be divided into three geographic regions. (1) The north region, consisting of the Tell Atlas and the Dorsale Mountains, separated by the fertile valley of the Majardah River, has average elevations of 300 to 1,000 m, reaching a peak elevation of 1,544 m at Jabal ash Shanabi. (2) South of the Dorsale Mountain chain, the semiarid central region, with poor soil and scanty vegetation, begins as an extensive plateau and gently slopes toward the eastern coastal plain of the Sahil. The central region's western half is known as the high steppe; its eastern half is the low steppe. This region includes Tunisia's offshore islands as well as its lowest point, Shatt al Gharsah, at -17 m. (3) The arid southern region is covered by the Sahara and consists of hills, low plateaus, and salt marshes or "s hatts." Land use is diverse, with 19% arable, 13% in permanent crops, 20% in permanent pasture (mainly in the mountain foothills), and 4% forested. About 3,850 sq km of land are irrigated.

b. Climate. Tunisia has two distinct Mediterranean-type seasons: a cool, rainy season from September to April, and a warm, dry season from May to August. The northern region has mean daily maximum and minimum temperatures of 32 °C and 18°C in the dry season, and 29°C and 8°C in the rainy season. Highs and lows are 46°C and 6°C in the dry season, and 42°C and -1°C in the rainy season. Humidity along the coast ranges between 60 and 70% from June through August. The central and southern regions have mean daily maximum and minimum temperatures of 38 °C and 15°C in the dry season, and 34°C and 4°C in the rainy season. Extreme highs and lows are 53 °C and 6°C in the dry season, and 47°C and 6°C in the rainy season. Rainfall is greatest in the north, between 460 mm and 1,500 mm annually, decreasing in the central region to between 200 mm and 400 mm, and in the southern desert region is less than 200 mm.

Tunis (elevation 66 m)

Mean Daily Temperatures (^{o}C)

MONTH	J	F	M	A	M	J	J	A	S	O	N	D
Maximum	14	16	18	21	24	29	32	33	31	25	20	16
Minimum	6	7	8	11	13	17	20	21	19	15	11	7

Mean Monthly Precipitation (mm)

	J	F	M	A	M	J	J	A	S	O	N	D
	64	51	41	36	18	8	3	8	33	51	48	61

c. Population and Culture. Although overall population density is 49 inhabitants per sq km, nearly 60% of the country's inhabitants are concent rated in the north and northeastern coastal region. One-third of the population lives in the Tunis metropolitan area, and approximately 45% of this population lives in slums. Ethnic make -up is 98% Arabs, 2% other. Religious preferences are 98% Muslim (m ostly Sunni), 1% Christian and 1% other. Total population 9.4 million, 60% urbanized, literacy rate 67%.

d. Water, Living and Sanitary Conditions. Extreme shortages of water usually occur from June through September in central and southern Tunisi a. Surface sources provide 65% of the water in the north and less than 40% in the south. The rest is obtained from ground aquifers. Over-extraction of water from artesian wells, especially along the northern coast, is causing rapid depletion and deterio ration of ground water supplies, and contributing to salt water intrusion. Rivers and streams throughout the country flow seasonally, except the Majardah River, which is perennial. Reservoirs are found throughout mountainous areas. Tunisia also has seve ral small desalinization plants. Many middle- and upper-income urban areas in Tunis have municipally filtered and chlorinated water supplied through individual house hookups, but contamination during distribution frequently occurs because of broken pipes and cross connections. This facilitates the spread of several enteric diseases and parasites, and supports breeding of rodents, mosquitoes and sand flies. Most residents throughout the rest of the country obtain water from public standpipes. Slums surro unding cities and most rural areas obtain water directly from untreated sources. Living and sanitary conditions in Tunisia generally are below Western standards. Although 75% of Tunisia's residences are connected to some type of sewage system, these syst ems vary from municipal sewer systems in the largest cities to septic tanks, cesspools, pit latrines, and simple ditches in the smaller urban areas. Virtually no public sewers exist in rural areas. Refuse is collected regularly only in Tunis and other ma jor cities, but often is improperly discarded on the outskirts of these cities. Shelters in shantytowns around many urban areas are constructed of discarded items or are similar to rural housing, which is mostly constructed of mud walls and thatched roofs . These conditions promote the transmission of several diseases of military importance, such as malaria, sand fly fever, hepatitis, and various types of dysentery.

V. Militarily Important Vector-borne Diseases with Short Incubation Periods (<15 days)

A. Malaria.

Human malaria is caused by any of four protozoan species in the genus *Plasmodium* that are transmitted by the bite of an infective female *Anopheles* mosquito. Clinical symptoms of malaria vary with the species. The most serious malaria infection, *falciparum* malaria, can produce life-threatening complications, including renal and hepatic failure, cerebral involvement, and coma. Case fatality rates among children and nonimmune adults exceed 10% when not treated. The other human malarias, *vivax*, *malariae* and *ovale*, are not life-threatening except in the very young, the very old, or persons in poor health. Illness is characterized by malaise, fever, shaking chills, headache, and nausea. The periodicity of the fever, occurring daily, every other day, or every third day, is characteristic of the species. Nonfatal cases of malaria are extremely debilitating. Relapses of improperly treated malaria can occur years after the initial infection in all but *falciparum* malaria. *Plasmodium malariae* infections may persist for as long as 50 years, with recurrent febrile episodes. Persons who are partially immune or have been taking prophylactic drugs may show an atypical clinical picture. Treatment of malaria has been complicated by the spread of multiple drug-resistant strains of *P. falciparum* in many parts of the world, but there are no reports of drug-resistance from North Africa. Current information on foci of drug resistance is published annually by the World Health Organization and can also be obtained from the Malaria Section of the Centers for Disease Control and Prevention, and the Armed Forces Medical Intelligence Center.

Military Impact and Historical Perspective. Malaria has had an epic impact on civilizations and military operations. During World War I, in the Macedonian campaign, the French army was crippled with 96,000 cases of malaria. During World War II malaria caused five times as many US casualties in the South Pacific as did enemy action. In 1942, malaria was the major cause of casualties in General Stilwell's forces in North Burma. There were approximately 81,000 confirmed cases of malaria in the US Army in the Mediterranean Theater from 1942 to1945. The average length of hospitalization for malaria in 1943 was 17 days, representing a total of 425,000 man-days lost during the year or the equivalent of an entire division lost for a month. In North Africa, the most highly malarious areas during World War II were in Rabat and Port Lyautey in Morocco, the Constantine coast area in Algeria, and the Tunis-Bizerte-Ferryville area in Tunisia. In 1952, during the Korean War, the 1st Marine Division suffered up to 40 cases per 1,000 marines. Battle causalities accounted for only 17% of American hospitalizations during the Vietnam War. Many regiments were rendered ineffective due to the incidence of malaria, and many US military units experienced up to 100 cases of malaria per 1,000 personnel per year. Elements of the 73rd Airborne Brigade had an incidence of 400 cases of malaria per 1,000 during 1967 and early 1968. Almost 300 military personnel contracted malaria during Operation Restore Hope in Somalia. Malaria remains a threat to military forces due to widespread drug resistance in plasmodia, insecticide resistance in the vectors, and resurgence of malaria in many areas of the world.

Disease Distribution. Endemic malaria has been eradicated from most temperate countries, but it still is a major health problem in many tropical and subtropical areas. Worldwide, there are an estimated 250 to 300 million cases of malaria annually, resulting in 2 to 3 million deaths. The WHO estimates that in Africa nearly one million children under the age of 10 die from malaria every year. Globally, *P. falciparum* and *P. vivax* cause the vast majority of cases. *Plasmodium falciparum* occurs in most endemic areas of the world and is the predominant species in Africa. *Plasmodium vivax* is also common in most endemic areas except Africa. *Plasmodium ovale* occurs mainly in Africa, and *P. malariae* occurs at low levels in many parts of the world. In most endemic areas the greatest malaria risk is in rural locations, with little or no risk in cities. However, in Somalia during Operation Restore Hope (1993), several malaria cases occurred in troops who were only in Mogadishu.

Malaria is not a major public health problem in North Africa or a threat to military forces operating in the region. However, the potential for transmission still exists in many areas. Increased population movement within as well as into North Africa as a result of improved air and road transportation, influxes of foreign workers from highly malarious parts of the world, and extensive water resource and agricultural development have increased the risk of malaria transmission. Malarious areas are confined primarily to parts of Algeria and Egypt. Current endemic areas are illustrated in Figure 1.

Algeria: Malaria used to be an important public health problem. More than 50,000 cases were reported annually from 1952 to 1961. Algeria launched an eradication program in 1968, together with the neighboring countries of Morocco and Tunisia and in collaboration with the WHO. The result was a drop in the annual incidence rate from 7 cases per 1,000 inhabitants in 1968 to less than 0.01 cases per 1,000 since 1976. Historically, the Sahara Desert has afforded northern Algeria a large measure of protection against malaria imported from countries to the south. The construction of the trans-Saharan highway linked the road networks of northern Algeria with those of West Africa, where *P. falciparum* predominates. Increased movement within and across the desert has increased the risk of importing *P. falciparum* and exotic vectors such as *Anopheles gambiae* and *Anopheles arabiensis* into Algeria. Water development and irrigation projects also increase the possibility that these species may become established.

Currently transmission risk is mostly limited to oases in the Sahara region in the provinces of Adrar, Illinzi, Ouargla, Tindourf and Tamanghasset from March through November. *Plasmodium vivax* accounts for nearly all cases. Less than 1% of infections are due to *P. falciparum*, and these cases are probably imported.

Canary Islands: The Canary Islands are considered malaria-free.

Egypt: Transmission occurs primarily from June through October. Malaria is endemic in focal areas of the Nile River Delta, Al Fayyum Governorate, and scattered oases, including Siwa Oasis and El Gara, a small oasis near Siwa. Possible risk exists along the Suez Canal, the northern Red Sea coast, and part of southern Egypt, including Luxor and

FIG. 1. MALARIA-ENDEMIC AREAS OF NORTH AFRICA (DARK SHADING)

Karnak, and rural areas outside Aswan. Urban centers, including Cairo and Alexandria, are malaria-free. Falciparum malaria is endemic only in Al Fayyum Governorate. *Plasmodium vivax* predominates in all other areas. Sporadic cases of *P. malariae* have been reported from oases.

Libya: Malaria has always been of low, localized endemicity, with the principal foci located in the southern region (Fezzan). In the western region (Tripolitania), malaria was endemic in the irrigated, fertile coastal areas but, due to low rainfall, the incidence remained low. In the more arid littoral areas of the eastern coastal region (Cyren aica), malaria has always been relatively uncommon. The principal *Plasmodium* infecting man has been *P. falciparum* in the south and *P. vivax* in the north. Countrywide, the rate of infection in the 1950s was estimated to be about 10 cases per 1,000 inhabit ants. Control measures were initiated in 1954, and the Kingdom of Libya and the WHO in 1960 organized a successful Malaria Eradication Program.

No indigenous cases have been officially reported since 1981; however, very low risk of transmission may be present from February to August in the valleys and isolated oases in southwest Libya (Fezzan), particularly near the municipalities of Awbari and Marzuq. Urban areas are malaria free. *Plasmodium vivax* predominates and all cases are classified as imported.

Morocco: Prior to the 1950s, malaria was an endemic disease with frequent epidemic outbreaks in summer and autumn. Extensive control operations by a central Malaria Eradication Service between 1965 and 1970 eradicated most known foci by 1973, although there was renewed transmission in ensuing years.

Malaria occurs in the southwestern part of the country in rural and urban areas up to 2,000 m in the Tihama coastal region and the Asir highlands (Jizan, Asir, and Al Bahah Provinces). In the west (Makkah and Al Madinah Provinces), it is limited to rural valley foci in the Hijaz Mountains. Malaria -free areas include the eastern, central and northern provinces, and the urban areas of Jeddah, Mecca, Medina and Taif in the western provinces. Nearly 99% of cases are caused by *P. vivax*. Transmission occurs year-round, with a higher incidence from October through April.

Tunisia: Indigenous malaria has not occurred since 1979, but foci of vivax malaria may still exist in isolated rural areas. From 1980 to 1995, 24 5 cases of imported malaria were recorded.

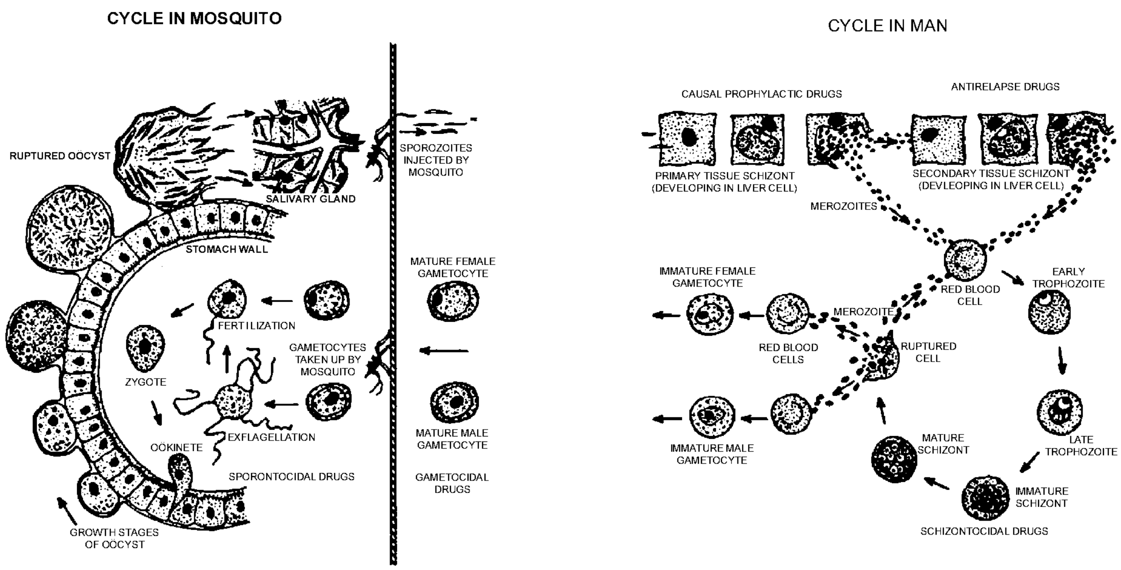
Transmission Cycle(s). Humans are the only reservoir host of human malaria. Nonhuman primates are naturally infected by many *Plasmodium* species that can infect humans, but natural transmission is rare. Female mosquitoes of the genus *Anopheles* are the exclusive vectors of human malaria. *Plasmodium* species undergo a complicated development in the mosquito. When a female *Anopheles* ingests blood containing the sexual stages (gametocytes) of the parasite, male and female gametes unite to form a motile ookinete that penetrates the mosquito's stomach wall and encysts on the outer surface of the midgut. Thousands of sporozoites are eventually released, and some of

these migrate to the salivary glands. Infective sp orozoites are subsequently injected into a human host when the mosquito takes a blood meal (Figure 2). The time between ingestion of gametocytes and liberation of sporozoites, ranging from 8 to 35 days, is dependent on the temperature and the species of *Plasmodium*. Malaria parasites develop in the mosquito vector most efficiently when ambient air temperatures are between 25 ^{o}C and 30^{o}C. Parasite development is prolonged during cool seasons and at high altitudes, and may exceed the life expectancy of the vector. Adult life span varies widely depending on species and environmental conditions. Longevity is an important characteristic of a good vector. Once infected, mosquitoes remain infective for life and generally transmit sporozoites at each subsequent feeding. Vector competence is frequently higher with indigenous strains of malaria. This decreases the likelihood that imported strains from migrants will become established.

Vector Ecology Profiles.
Worldwide, about 70 species of *Anopheles* transmit malaria to man, but of these only about 40 are important vectors. The vector status in North Africa is relatively uncomplicated, because there are few anopheline species that successfully exploit an arid environment. Primary malaria vectors are present in each country of North Africa, except the Canary Islands. Primary vectors include *Anopheles pharoensis* (only in Egypt), *An. multicolor* and *An. sergentii* (both widespread, including southern Morocco). Secondary vectors include *An. claviger* (Tunisia, northern Morocco, and Algeria), *An. hispaniola* (Canary Islands, Sinai, Morocco, Tunisia, and the deserts of southwestern Libya) and *An. labranchiae* (Libya, Tunisia and Algeria). *Anopheles superpictus*, reported from the Sinai and fr om oases in southwestern Egypt and Libya, has a limited distribution, and is considered a secondary vector. Introduction of *An. arabiensis* or *An. gambiae* into southern Libya from Niger is possible due to extensive ground traffic between the two countries. There are a number of other *Anopheles* species present in the region, but they are not known to be malaria vectors (see Appendix A.1.). The habitats and general bionomics of malaria vectors are summarized in Appendix B.1. Seasonal peaks for each vector and country are variable, depending on individual mosquito species, breeding site preferences and rainfall patterns.

General Bionomics. Female anopheline mosquitoes must ingest a bloodmea l in order for their eggs to develop. Feeding activity begins at dusk for many species, although many others feed only later at night or at dawn. Most anophelines feed on exposed legs, although some may feed on arms, ears or the neck. Infected females t end to feed intermittently and thus may bite several people. Eggs mature in 3 to 4 days and are deposited one at a time, primarily in clean water with or without emergent vegetation, depending upon the mosquito species. A single female may deposit up to 200 eggs. Mosquito larvae feed on organic debris and minute organisms living in aquatic habitats. Oviposition sites include ground pools, stream pools, slow moving streams, animal footprints, artificial water vessels and marshes. Deep water (over one me ter in depth) is generally unsuitable for larval development. There are 4 larval instars, and 1 to 2 weeks are usually required to reach the nonfeeding pupal stage. The pupa is active and remains in the water for several days to a week prior to adult eme rgence. The life span of females is usually only 2 to 3 weeks, although under ideal conditions female mosquitoes may live

Figure 2. LIFE CYCLE OF PLASMODIUM THE MALARIA PARASITE



for 2 to 3 months. Longevity of individual species varies. A long life span is an important characteristic of a good vector. The older the anopheline population is in an endemic area, the greater the potential for transmission. Males live only a few days. Females mate within swarms of males, usually one female per swarm. Males and females both feed on plant sugars and nectar to provide energy for flight and other activities.

Adult Feeding, Resting, and Flight Behavior. *Anopheles* spp. that are strongly attracted to humans are usually more important as vectors than those species that are strongly zoophilic. *Anopheles* generally fly only short distances from their breeding sites. The flight range is the distance traveled from the breeding site over the course of the mosquito's lifetime. This is important when determining how far from military cantonments to conduct larviciding operations. Vectors that feed and rest indoors are more susceptible to control by residual insecticides.

Specific Larval Habitats:

An. claviger – develops in wells and cisterns; requires cool water for larval development.

An. hispaniola – little is known about this species, except that it inhabits oases.

An. labranchiae – develops in fresh or brackish marshes, swamps, or irrigated fields; tolerates warm water habitats, particularly in coastal areas.

An. multicolor – lives in shallow ponds and pools in and around cultivated fields. It can also live in polluted urban impoundments, slow-moving streams, or seepages with high salinity. Larvae will not tolerate sewage.

An. pharoensis – develops in marshes, swamps, and rice fields. Prefers aquatic areas with emergent vegetation, especially if overgrown with shady vegetation.

An. sergentii – develops in freshwater seepages, shallow wells, and irrigation systems for date palms and other cultivated crops. Tolerates lack of shade and emergent vegetation.

An. superpictus – develops in clear, sunlit water, usually without vegetation.

Adult Feeding, Resting, and Flight Behavior:

An. claviger – bites man and domestic animals indoors and outdoors. Rests indoors or outdoors after feeding. Considered a short-range flier, but the actual range is unknown.

An. hispaniola – little is reported on this species, except that it inhabits oases.

An. labranchiae – feeds on man and domestic animals. Rests indoors or outdoors after feeding. The specific flight range is unknown. Seasonal increases in adult biting activity usually begin in March.

An. multicolor – feeds on man and domestic animals, and attacks humans only in the absence of animals. Feeds and rests indoors and outdoors, often preferring indoor or animal pen resting areas. No flight range information is available.

An. pharoensis – bites animals preferentially, feeding on man in their absence. Feeds indoors and outdoors. Rests outdoors after feeding. This species is a strong flier, with a range of 10 km or more.

An. sergentii – feeds on animals and man, both indoors and outdoors. Rests in animal shelters or human dwellings after feeding. This species is a moderately strong flier, with a range that may exceed 5 km.

An. superpictus – feeds on man and animals, both indoors and outdoors. Rests in human dwellings, caves, or animal shelters after feeding. Generally a short - to medium-range flier, rarely travelling more than 5 km from its larval habitat.

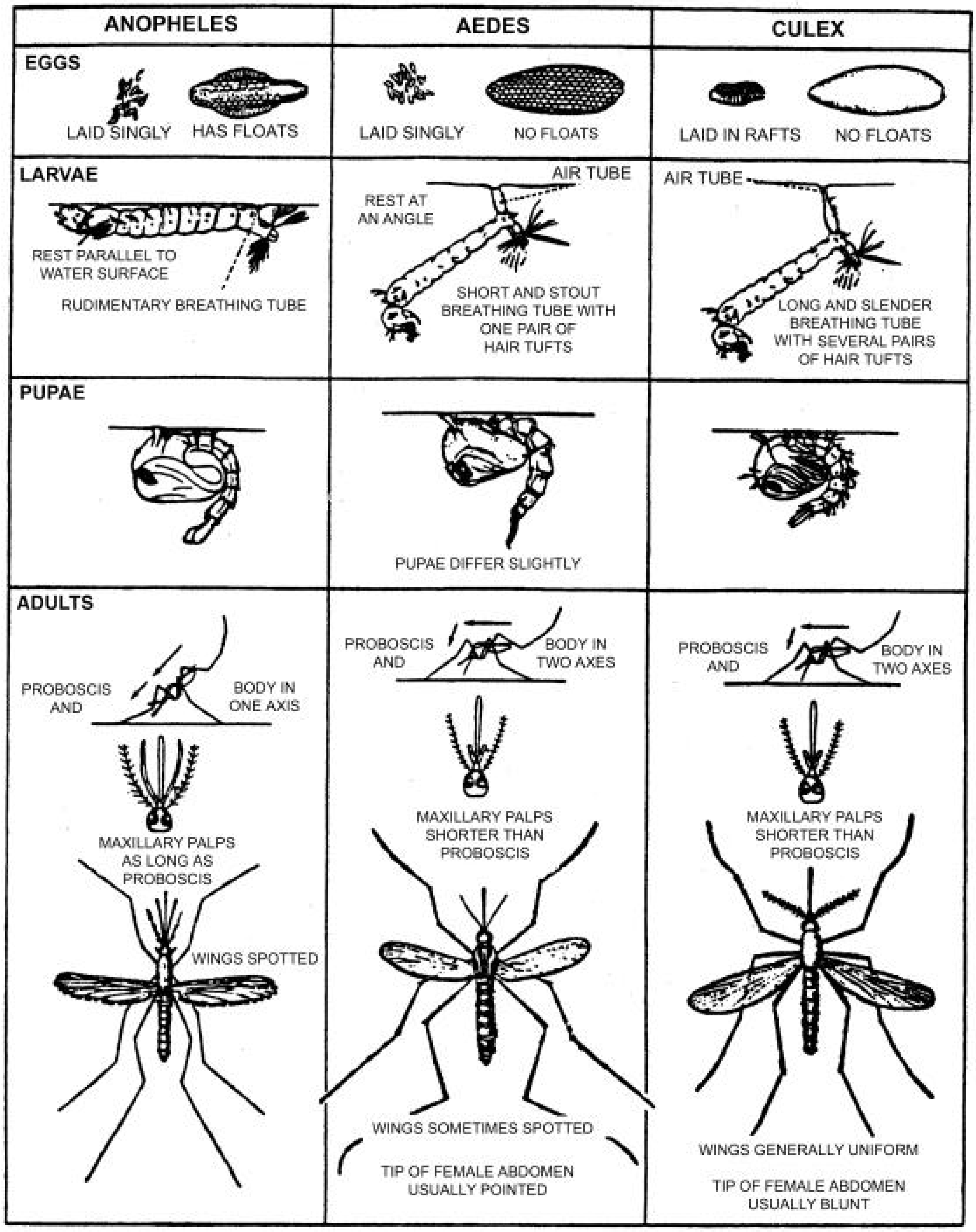
Vector Surveillance and Suppression. Light traps are used to collect night-biting mosquitoes, but not all *Anopheles* spp. are attracted to light. The addition of the attractant carbon dioxide to light traps increases the number of species collected. Traps using animals, or even humans, as bait are useful for determining feeding preferences of mosquitoes collected (use of humans as bait must be conducted under approved human-use protocols). Adults are often collected from indoor and outdoor resting sites using a mechanical aspirator and flashlight. Systematic larval sampling with a long-handled white dipper provides information on species composition and population dynamics that can be used to plan control measures.

Anopheles mosquitoes have unique morphological and behavioral characteristics that distinguish them from all other genera of mosquitoes (Figure 3.). *Anopheles* feed on the host with the body nearly perpendicular to the skin. Other genera of mosquitoes feed with the body parallel or at a slight angle to the skin. These characteristics can easily be used by inexperienced personnel to determine if *Anopheles* are present in an area.

Malaria suppression includes elimination of gametocytes from the blood stream of the human reservoir population, reduction of larval and adult *Anopheles* mosquito populations, use of **personal protective measures** such as skin repellents, permethrin-impregnated uniforms and bednets to prevent mosquito bites, and chemoprophylaxis to prevent infection. Specific recommendations for chemoprophylaxis depend on the spectrum of drug resistance in the area of deployment. Command enforcement of chemoprophylactic measures cannot be overemphasized. When Sir William Slim, British Field Marshal in Southeast Asia during World War II, strictly enforced chemoprophylactic compliance by relieving inattentive officers, malaria attack rates declined dramatically. During the Vietnam War, malaria attack rates dropped rapidly in military personnel when urine tests were introduced to determine if chloroquine and primaquine were being taken.

Many prophylactic drugs, such as chloroquine, kill only the erythrocytic stages of malaria and are ineffective against the latent hepatic stage of *Plasmodium* that is responsible for relapses. Therefore, even soldiers who take chloroquine appropriately during deployment can become infected. Individuals who are noncompliant with the prescribed period of terminal prophylaxis are at risk for late relapses upon their return to the United States. During the Vietnam War, 70% of returning troops failed to complete their recommended terminal prophylaxis. The majority of cases in military personnel returning from Operation Restore Hope in Somalia resulted from failure to take proper terminal prophylaxis.

FIGURE 3. ANOPHELES, AEDES, AND CULEX MOSQUITOES



Application of residual insecticides to the interior walls of buildings and sleeping quarters is an effective method of interrupting malaria transmission when local vectors feed and rest indoors. Nightly dispersal of ultra low volume (ULV) aerosols can reduce exophilic mosquito populations. Larvicides and biological controls (e.g., larvivorous fish) can reduce populations of larvae at their aquatic breeding sites before adults emerge and disperse. Insecticides labeled for mosquito control are listed in TIM 24, Contingen cy Pest Management Pocket Guide. Chemical control may be difficult to achieve in some areas. After decades of malaria control, many vector populations are now resistant to insecticides (Appendix C. Pesticide Resistant Arthr opods in North Africa). Sanitary improvements, such as filling and draining areas of impounded water to eliminate breeding habitats, should be used to the extent possible.

The proper use of repellents and other **personal protective measures** is thoroughly discussed in TIM 36, Personal Protective Techniques Against Insects and Other Arthropods of Military Significance. The use of bednets impregnated with a synthetic pyrethroid, preferably permethrin, is an extremely effective method of protecting sleeping individuals from mosquito bites. Buildings and sleeping quarters should be screened to prevent entry of mosquitoes and other blood-sucking insects. The interior walls of tents and bunkers can be treated with permethrin to control resting vectors. See Appendix F for further information on **personal protective measures**.

B. Sand fly Fever. (Papatasi fever, Three-day fever)
The sand fly fever group of viruses (*Phlebovirus*, Bunyaviridae) contains at least seven immunologically related types. Naples, Sicilian and Toscana are normally associated with sand fly fever. The virus produces an acute febrile illness lasting 2 to 4 days and is commonly accompanied by headache and muscle pain. There is usually no mortality or significant complications associated with infections of Naples or Sicilian viruses, although weakness and depression may persist a week or more after the acute illness. However, Toscana virus may cause central nervous system disease in addition to fever. Most infections are acquired during childhood in endemic areas. The clinical disease in children is generally mild and results in lifelong immunity to homologous strains.

Military Impact and Historical Perspective. Sand fly fever has been an important cause of febrile disease during military operations since at least the Napoleonic Wars. In 1909, an Austrian military commission first reported that an infectious agent found in the blood of infected soldiers caused this fever, and that the vector was the sand fly. During World War II, sand fly fever attained importance in Allied and Axis forces in the Mediterranean theater by incapacitating large numbers of men for periods of 7 to 14 days. The disease was first recognized in US forces in North Africa in Apri l of 1943. Although several thousand cases were reported from 1943 to 1945 in the Mediterranean Theater, the incidence of sand fly fever was undoubtedly underestimated. Many thousands of cases of sand fly fever were probably recorded as fevers of unknown origin, since most medical officers were unfamiliar with the disease and specific tests for diagnosis were not available. In sharp contrast to World War II, there were no reports of sand fly fever among coalition forces during the Persian Gulf War. The military significance of sand fly fever is magnified because of its short incubation period, which may result in large

numbers of nonimmune troops being rendered ineffective early in an operation, while endemic forces would be largely immune and unaffected .

Disease Distribution. Sand fly fever is widespread in focal areas of North Africa. Transmission occurs in most areas primarily from April through November, when sand flies are most active.

Algeria: Foci may occur countrywide, with the highest risk of transmission in village and periurban areas along the coast and in the steppe area of the northern Algerian Sahara.

Egypt: Foci are distributed countrywide, including the Nile River Delta, Nile Valley, Sinai Peninsula, and Suez Canal Zone. The highest r isk of transmission exists in villages and periurban areas. Both the Sicilian and Naples viruses circulate in Egypt. Surveys in the Nile River Delta during early 1991 found 4 and 2 % of tested individuals seropositive to Sicilian and Naples viruses, resp ectively. Up to 29% of the children in Abou Sati village in the Nile River Delta were seropositive in the early 1990s.

Libya: Sand fly fever is endemic countrywide, with the highest risk of transmission in villages and periurban coastal areas. Based on data from neighboring Egypt, Sudan, and Tunisia, both the Sicilian and Naples viruses probably circulate in Libya.

Morocco: Foci occur countrywide, although the greatest risk of transmission occurs in village and periurban areas throughout the northern ha lf of Morocco. Both the Naples and Sicilian serotypes have been detected.

Tunisia: Significant risk of transmission exists in the northern, central and southeastern areas of the country. Both the Sicilian and Naples serotypes are endemic.

Transmission Cycle(s). No vertebrate reservoir has been established, but there is some serological evidence that gerbils serve as reservoirs. Infected humans can infect sand flies and thus have an amplifying effect during epidemics. Humans with high levels of virus in the blood more easily infect sand flies. The principal reservoir mechanism appears to be transovarial transmission within the vector. The virus is most efficiently replicated in the sand fly vector and transmitted when temperatures exceed 25 ^{o}C. Infected sand flies remain infective for life and are not harmed by the virus.

Vector Ecology Profiles.
Phlebotomus papatasi is the primary vector in the region. *Phlebotomus sergenti* is a suspected vector. *Phlebotomus papatasi* is widely distributed throughout the region and has been reported from every country in North Africa. This species tends to be more rural and periurban in distribution because it requires warm, humid microhabitats, such as animal burrows, for larval development. *Phlebotomus sergenti* is also widely distributed but is not as ubiquitous as *P. papatasi.* A list of sand fly species and their distribution in North Africa appears in Appendix A.2.

Some *P. papatasi* are autogenous; that is, they are capable of producing small numbers of eggs without a bloodmeal, at least during the first gonotrophic cycle. After a bloodmeal females deposit eggs, 30 to 70 at a time, in gerbil or other rodent burrows, poultry houses, masonry cracks, rock crevices, leaf litter, or moist tree holes. Eggs hatch in 1 to 2 weeks, and larvae develop in warm, moist microhabitats that provide abundant organic matter for food. In military fortifications, larvae may live in the cracks between stacked sandbags. There are 4 larval instars, and 4 to 8 weeks are required to reach the pupal stage. Fourth instar larvae may diapause for weeks or months if environmental conditions are excessively cold or dry. Alternatively, if environmental conditions improve, diapause may be quickly broken. Pupation occurs in the larval habitat. There is no cocoon; rather, the pupa is loosely attached to the substrate by the cast skin of the 4th larval instar.

Phlebotomus papatasi feeds most intensely at dusk and dawn, with some feeding continuing sporadically through the rest of the night. *Phlebotomus papatasi* and *P. sergenti* are both endophilic and follow odor plumes to their hosts. Only females take blood, but both sexes feed on plant sugars and nectar. Besides humans, female sand flies feed on the blood of a variety of birds and mammals; though most frequently in dogs, gerbils, and hedgehogs. On humans, they feed on exposed skin around the head, neck, legs, and arms. Female sand flies will crawl under the edges of clothing to bite skin where repellent hasn't been applied. Sand flies feed outdoors or indoors and readily penetrate ordinary household screening. After engorgement, *P. papatasi* and other sand flies rest briefly on objects near their host, then move to gerbil burrows or other cool, moist environments to lay eggs. They also rest in caves and other areas that are relatively cool and shaded during the daytime.

Sand flies are weak fliers and do not travel in wind that exceeds a few kilometers per hour. *Phlebotomus papatasi* may be active at low relative humidities of 45 to 60%, but other vector species require 75 to 80% relative humidity in order to fly and feed. Sand flies fly in short hops, which usually limits their feeding radius to about 100 to 200 m from pupation sites. However, unengorged females may occasionally disperse as far as 1.5 km. Mating dances occur on the ground, often at dusk, with males landing first, followed by females.

Vector Surveillance and Suppression. Because sand flies are small and secretive, specialized methods are required to collect them. The simplest method is active searching of daytime resting sites with an aspirator and flashlight, but this method is very labor intensive. Human-landing collections are an important method of determining which species are anthropophilic. Sticky traps (paper coated with a sticky substance or impregnated with castor oil) are used to randomly capture sand flies moving to or from resting places. Traps can also be placed at the entrances of animal burrows, caves and crevices, in building debris, and in local vegetation where sand flies are likely to rest during daytime hours. A variety of light traps have been used to collect phlebotomines, but their effectiveness varies according to the species being studied and the habitat. Light traps are inefficient in open desert but their effectiveness can be increased if they are placed close to rodent burrows, termite mounds and other sheltered animal habitats. Light traps used for mosquito collection should be modified with fine mesh netting in

order to collect sand flies. Traps using animals as bait have also been devised. Collection of larvae is extremely labor intensive and usually unsuccessful because specific breeding sites are unknown or hard to find because females deposit eggs singly over a wide area. Emergence traps are useful for locating breeding sites. Identification of sand flies requires a microscope and some training; however, with a little experience, sorting and identification by color and size is quite accurate using minimal magnification. For proper species identification, laboratory microscopes having 100x magnification are required.

Because of their flight and resting behavior, sand flies that feed indoors are very susceptible to control by residual insecticides. When sand flies are exophilic or bite away from human habitations, control with insecticides is impractical, although the application of residual insecticides to depth of 100 m around encampment sites may be useful. Some success in reducing vector populations has been achieved by controlling the rodent reservoir or host population. Selection of encampment sites without vegetation or rock outcroppings that harbor rodents is important. Cleanup and removal of garbage and debris that encourage rodent infestation are necessary for longer periods of occupation. Pets must be strictly prohibited, because any small desert rodent and/or local dog may be infected with leishmaniasis or other infectious diseases.

Sand flies are able to penetrate standard mesh screening used on houses and standard mesh bednets (7 threads per cm or 49 threads per sq cm). These items should be treated with permethrin to prevent entry. Fine mesh (14 threads per cm or 196 threads per sq cm) bednets must be used, but these are uncomfortable under hot, humid conditions because they restrict air circulation. The use of repellents on exposed skin and clothing is the most effective means of individual protection. Insect repellent should be applied to exposed skin and to skin at least two inches under the edges of the BDU to prevent sand flies from crawling under the fabric and biting. The use of **personal protective measures** (see TIM 36) is the best means of preventing sand fly-borne disease.

C. Dengue Fever. (Breakbone fever, Dandy fever)
Dengue is an acute febrile disease characterized by sudden onset, fever for 3 to 5 days, intense headache, and muscle and joint pain. It is commonly called breakbone fever because of the severity of pain. There is virtually no mortality in classical dengue. Recovery is complete, but weakness and depression may last several weeks. Dengue is caused by a *Flavivirus* and includes four distinct serotypes (dengue 1, 2, 3 and 4). Recovery from infection with one serotype provides lifelong immunity from the same serotype but does not provide protection against other serotypes. Dengue hemorrhagic fever (DHF) and associated dengue shock syndrome (DSS) were first recognized during a 1954 dengue epidemic in Bangkok, Thailand. DHF/DSS have spread throughout Southeast Asia, Indonesia and the southwest Pacific, Latin America and the Caribbean. DHF requires exposure to two serotypes, either sequentially or during a single epidemic involving more than one serotype. DHF is a severe disease that produces high mortality in children.

Military Impact and Historical Perspective. Dengue virus was first isolated and characterized in the 1940s, but dengue fever can be identified clinically from the 18th century. Epidemics of dengue are noted for affecting large n umbers of civilians or military forces operating in an endemic area. Outbreaks involving 500,000 to 2 million cases have occurred in many parts of the world. During World War II, the incidence of dengue was largely restricted to the Pacific and Asiatic t heaters. Only scattered cases of dengue were reported from other theaters, including North Africa. Campaigns in the Pacific were marked by dengue epidemics, and throughout the war the US Army experienced nearly 110,000 cases. At Espiritu Santo in the Pa cific, an estimated 25% of US military personnel became ill with dengue, causing a loss of 80,000 man -days. Dengue was an important cause of febrile illness among US troops during Operation Restore Hope in Somalia. In recent years dengue, especially DHF , has been expanding throughout the world. Thirty to 50 million cases of dengue are reported annually.

Disease Distribution. Dengue is present in nearly all tropical countries. Its distribution is congruent with that of its primary vector, *Aedes aegypti*, between 40° N and 40° S latitude. Epidemics generally coincide with the rainy season and high mosquito populations. Increasing urbanization and discarded litter have increased breeding habitats for dengue vectors. Few if any cases of dengue are repor ted from North Africa. Dengue was reported from Egypt in the 1950s, but the current risk of transmission there is limited to extreme southeastern coastal areas. *Aedes aegypti* is present in neighboring Sudan, where cases of dengue were reported from coast al areas during the 1980s.

All dengue serotypes are now endemic in sub -Saharan Africa. In recent years, outbreaks of dengue fever have occurred on the east coast of Africa from Mozambique to Ethiopia and on such offshore islands as the Seychelles and Co moros. These endemic areas could be a source of reintroduction of the virus into North Africa.

Transmission Cycle(s). Dengue virus is exclusively associated with *Aedes* mosquitoes in the subgenus *Stegomyia*. The virus is maintained in a human -*Ae. aegypti* cycle in tropical urban areas. A monkey-mosquito cycle serves to maintain the virus in sylvatic situations in Southeast Asia and West Africa. Mosquitoes are able to transmit dengue virus 8 to 10 days after an infective blood meal and can transmit the vi rus for life. Dengue virus replicates rapidly in the mosquito at temperatures above 25 °C.

Vector Ecology Profiles.
Aedes aegypti, the primary vector in most endemic areas, is reported as eradicated from Egypt and the Canary Islands. Recently, it has been reported only from Morocco, but it still may occur in urban coastal areas of Algeria, Libya and Tunisia.

This species is more common in cities or villages than in rural areas. *Aedes aegypti* deposits its eggs singly or in small groups of 2 to 20 abo ve the water line of its habitat. Larvae emerge after eggs have been submergence for 4 or more hours . *Aedes aegypti* larvae live in artificial water containers, including flowerpots, cisterns, water jugs, and tires. Larvae prefer relatively clean, clear water. They develop quickly in warm water, maturing to the pupal stage in about 9 days. Pupae remain active in the water container

until adult emergence, 1 to 5 days after pupation. *Aedes aegypti* rarely disperse more than 50 m from its breeding site, b ut over several days, it could disperse as far as 500 to 600 m. It does not fly when winds exceed 5 km per hour.

Aedes aegypti prefers human hosts and feeds primarily around human habitations. It is a diurnal feeder and readily enters homes. *Aedes aegypti* is not attracted to light; rather, it responds to contrasting light and dark areas presented by human dwellings. When feeding outdoors, it prefers shaded areas. It feeds on the lower legs and ankles, increasing its biting activity when temperatures and humidity are high. It is easily disturbed when feeding and, because it feeds during the day, is often interrupted by the movements of its host. This behavior results in multiple bloodmeals, often taken within the same dwelling, which increases trans mission of virus.

Aedes caspius is the most widespread potential vector in North Africa and has been recorded from the Canary Islands, Egypt, Libya, Morocco and Tunisia. If dengue outbreaks occur in North Africa, *Ae. caspius* will probably be the primary vector. This species is more prevalent in areas with shallow, sunlit, saline, stagnant ground pools with or without vegetation, and with moderate rainfall. It may be found in isolated stream pools, ground pools, date palm plots, and overflow water from irrigation projects. It is common in coastal areas. Although this species is frequently found alone, it is sometimes associated with larvae of *Anopheles sergentii* and *Culex pusillus* in its freshwater habitats. It is also found with *Culex pipiens pipiens* and *Culex univittatus* in water with high organic content. *Aedes caspius* is an opportunistic feeder that attacks birds and large mammals, including cattle, sheep and humans. It feeds primarily outdoors and can develop up to 2 egg batches autogenously. E ggs are deposited singly or in small groups directly on the water surface. Larvae emerge 2 to 3 days after deposition.

Aedes albopictus was first discovered in southeastern Nigeria in Delta and Benue States in 1991 and has subsequently spread to Imo, An ambra and Enugu States. *Aedes albopictus* has been spreading rapidly in Italy since its accidental introduction in 1990, it is possible that this important vector may spread to coastal Mediterranean areas of North Africa. It is more common in rural than u rban areas. *Aedes albopictus* has larval and adult feeding habits similar to *Ae. aegypti* but is more commonly found breeding in natural containers, such as tree holes, leaf axils, and fallen fruit husks. Eggs and larvae have been introduced into new areas by infested tires. It is a slightly stronger flier than *Ae. aegypti. Aedes albopictus* is strongly anthropophilic but has a broader host range than *Ae. aegypti.*

Vector Surveillance and Suppression. Landing rate counts provide a quick relative index of adult abundance. The number of mosquitoes that land on an individual within a short period of time, usually 1 minute, is recorded. Several indices have been devised to provide a relative measure of the larval populations of *Ae. aegypti.* The house index is the percentage of residences surveyed that have containers with larvae of dengue vectors. The container index is the percentage of containers at each premise that have larvae of dengue vectors. The Breteau index is more widely used and is the number of positive containers per 100 premises. There is a risk of dengue transmission when the Breteau

index goes above 5, and emergency vector control is indicated when the index exceeds 100. Adult egg-laying activity can be monitored using black oviposition traps.

Control of dengue fever is contingent upon reducing or eliminating vector populations. Ground or aerial applications of insecticidal aerosols have been relied upon to reduce adult populations during epidemics of dengue. Many vector control speci alists have questioned the efficacy of ULV adulticiding. In some outbreaks of dengue fever, ULV dispersal of insecticides has had only a modest impact on adult mosquito populations. *Aedes aegypti* is a domestic mosquito that frequently rests and feeds ind oors and therefore is not readily exposed to aerosols. The sides of large storage containers should be scrubbed to remove eggs when water levels are low. Water should be stored in containers with tight-fitting lids to prevent access by mosquitoes. A lay er of oil will prevent mosquito eggs from hatching and will kill the larvae. The elimination of breeding sources, such as old tires, flowerpots, and other artificial containers, is the most effective way to reduce mosquito populations and prevent dengue outbreaks. In Singapore, passage of sanitation laws and their strict enforcement to eliminate breeding sites reduced the house index for *Ae. aegypti* larvae from 25% to 1%. Proper disposal of trash, bottles and cans at military cantonments must be rigidl y enforced. The individual soldier can best prevent infection by using **personal protective measures** during the day when vector mosquitoes are active. Wear permethrin-impregnated BDUs and use extended-duration DEET repellent on exposed skin surfaces (see TIM 36).

D. Epidemic Typhus.

Epidemic typhus is a severe disease transmitted by the human body louse, *Pediculus humanus humanus*. The infectious agent is the bacterium *Rickettsia prowazekii*. It causes high mortality, particularly in populations weakened by malnutrition. Case fatality rates normally vary from 10 to 40% in the absence of specific therapy. Onset is usually sudden and marked by fever, headache, and general pains followed by a rash that spreads from the trunk to the entire body. Untreated cases of epidemic typhus may last up to 3 weeks.

Military Impact and Historical Perspective. Epidemics of typhus have changed the course of history. One author has stated that the louse has killed more soldiers than all the bullets fired during conflic t. In one of the worst disasters in military history, over half of Napoleon's army perished from epidemic typhus during the invasion of Russia in 1812. During the first year of World War I, typhus started as an epidemic in the Serbian Army. In 6 months, 150,000 people had died of the disease, including 50,000 prisoners of war and one-third of the Serbian physicians. By the end of the war and during the period immediately following it (1917 to 1923), an estimated 30 million cases of epidemic typhus occurred in Russia and Europe, with over 300,000 deaths. During World War II, there were severe epidemics of typhus in some endemic areas. From 1941 to 1944, there were over 132,000 cases in urban areas of French North Africa. Over 91,000 cases occurred in Egypt during this same period. Despite this incidence, US Army personnel experienced only 30 cases of typhus with no typhus deaths in the North African-Middle East-Mediterranean zone during the years 1942 to1945. When Allied forces landed in Italy in 1943, a typhus epidemic in Naples was ravaging the city of one

million. Death rates reached 80%. An effective delousing campaign, chiefly using DDT, was waged. This marked the first time in history that an epidemic of typhus did not exhaust itself but instead was terminated by human action. The U.S. Army achieved a remarkable record of low morbidity with no fatalities from epidemic typhus in World War II by taking effective protective measures against the disease and through the work of the US Typhus Commission established by the Secretary of War on October 22, 1942.

The development of modern antibiotics and insecticides has reduced the threat of this disease to military forces. However, the short incubation period and severe clinical symptoms of epidemic typhus should be of concern to medical personnel when dealing with large concentrations of refugees and prisoners of war. The persistence of epidemic typhus foci in North Africa necessitates consideration of this disease when planning future military operations in the region.

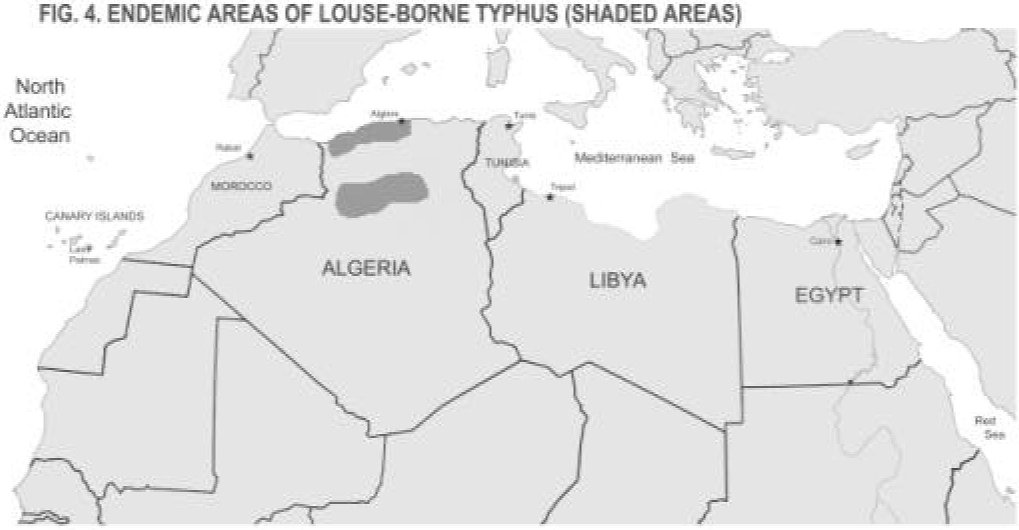
Disease Distribution. Epidemic typhus is more common in temperate regions and in the cooler tropics above 1600 m. It is absent from lowland tropics. It usually occurs in mountainous regions where heavy clothing is worn continuously , such as the Himalayan region, Pakistan and Afghanistan, and the highlands of Ethiopia. The incidence of epidemic typhus has been steadily declining in the last 2 decades. The majority of recent cases have occurred in Africa, primarily in Ethiopia, with most of the remainder occurring in Peru and Ecuador. Historically, epidemic typhus has been recorded throughout North Africa, with foci in coastal and northern Algeria. In 1998, a person returning to France after a three month visit to Msila, a small to wn in east central Algeria, was diagnosed with epidemic typhus. Recognized foci also occur in western and coastal Libya and among nomads. Louse-borne typhus is still considered endemic in rural villages of Egypt (Figure 4).

Transmission cycle(s). The head louse, *Pediculus humanus capitis*, and the crab louse, *Pthirus pubis*, can transmit *R. prowazekii* experimentally, but epidemics have always been associated with the body louse, *P. h. humanus*. Humans are reservoirs of the pathogen and the only hosts for the lice . Transmission of the disease occurs when individuals wear the same clothes continuously under crowded, unsanitary conditions. Major epidemics have been associated with war, poverty and natural disasters. Persons in cold climates are more likely to acquire epidemic typhus when they are unable to bathe or change clothes for long periods of time.

Lice become infective after a blood meal from an infected human. During subsequent blood meals, the louse defecates and rickettsiae are excreted in the feces. Louse bites are irritating, and scratching by the host produces minor skin abrasions, which allow entry of the pathogen from feces or crushed body lice. *Rickettsia prowazekii* can survive desiccation for several weeks. Infection may also occur by inhalation of infective louse feces.

The survival of *R. prowazekii* between outbreaks is of interest, since there is no transovarial transmission and lice die from the infection. A milder form of epidemic typhus known as Brill-Zinsser disease occurs in individuals who recover from the initial

FIG. 4. ENDEMIC AREAS OF LOUSE-BORNE TYPHUS (SHADED AREAS)



infection and relapse years later. Lice feeding on such patients become infected. These relapsed individuals are considered to be the main reservoir of *R. prowazekii* in eastern Europe. A sylvatic cycle of *R. prowazekii* has been recognized in the southeastern United States, where flying squirrels and their ectoparasites (the flea *Orchopeas howardii* and the louse *Neohaematopinus sciuropteri*) are naturally infected. The louse is host specific, but *O. howardii* has an extensive host range, which includes humans. Sporadic human cases have occurred in houses harboring flying squirrels. The significance of this finding to the epidemiology of epidemic typhus in other areas is not known.

Vector Ecology Profile.
Human lice spend their entire life cycle (egg, 3 nymphal stages and adult) on the host. Eggs of body lice are attached to clothing at a rate of about 5 eggs per female per day. At 29°C to 32°C, eggs hatch in 7 to 10 days. The maximum time eggs can survive unhatched is 3 to 4 weeks, which is important when considering the survival of lice in infested clothing and bedding. A bloodmeal is required for each of the 3 nymphal molts and for egg production in adults. The nymphal stages are passed in 8 to 16 days. Louse populations have the potential to double every 7 days. Adults live about 2 weeks and feed daily. Infestations of lice cause considerable irritation and scratching, which may lead to skin lesions and secondary infections. Body lice are commonly found in the seams and folds of clothing. Lice tolerate only a narrow temperature range and will abandon a dead host or one with a body temperature of 40 °C or above. This contributes to the spread of lice and louse-borne disease. Human lice can survive without a host for only a few days.

Vector Surveillance and Suppression. Surveillance for body lice consist of examining individuals and their clothing for lice or nits (eggs). Body louse infestations have declined with higher standards of living, although infestations are still common in some North African populations, especially nomads. Military personnel should avoid close personal contact with infested persons and their belongings, especially clothing and bedding. Dry cleaning or laundering clothing or bedding in hot water (55 °C for 20 minutes) will kill eggs and lice. Control of epidemics requires mass treatment of individuals and their clothing with effective insecticides. The permethrin-treated BDU is extremely effective against lice. Since lice cannot survive away from the human host, application of insecticides to buildings, barracks or other living quarters is not necessary. Pesticide resistance to common pediculicides, particularly DDT, gamma BHC (lindane) and malathion, is widespread in the region.

Production of typhus vaccine in the United States has been discontinued, and there are no plans for commercial production of a new vaccine. Vaccination against typhus is not required by any country as a condition of entry.

E. Relapsing Fever (louse-borne). (Epidemic relapsing fever)
Louse-borne relapsing fever is caused by the spirochete *Borrelia recurrentis*. The symptoms and severity of relapsing fever depend on the immune status of the individual, geographic location, and strain of *Borrelia*. The incubation period in an infected host ranges from 2 to 14 days. The disease is characterized by a primary febrile attack

followed by an afebrile interval and one or more subsequent attacks of fever and headache. Intervals between attacks range from 5 to 9 days. In untreated cases, mortality is usually low but can reach 40%. Infection responds well to treatment with antibiotics.

Military Impact and Historical Perspective. Major epidemics of louse-borne relapsing fever occurred during World War I and the war's aftermath in Russia, Central Europe and North Africa. After the war, relapsing fever was disseminated through large areas of Europe, carried by louse-infested soldiers, civilians and prisoners of war. Between 1910 and 1945, there were an estimated 15 million cases and nearly 5 million deaths. Large outbreaks of relapsing fever were common during and after World War II. During World War II, epidemics of louse-borne relapsing fever in North Africa produced an estimated one million cases and some 50,000 deaths. During the Vietnam War, epidemics of louse-borne fever occurred in the Democratic Peoples' Republic of Vietnam.

Disease Distribution. From 1960 to 1980, louse-borne relapsing fever flourished primarily in the Sudan and Ethiopia. Ethiopia reported the highest number of cases, with an estimated 10,000 cases per year. Epidemics usually occur in the cold season, among poor people with inadequate hygiene. Sporadic cases of louse-borne relapsing fever have been reported in North Africa, but the risk of transmission is considered low. The areas where the greatest risk of transmission occurs are depicted in Figure 5.

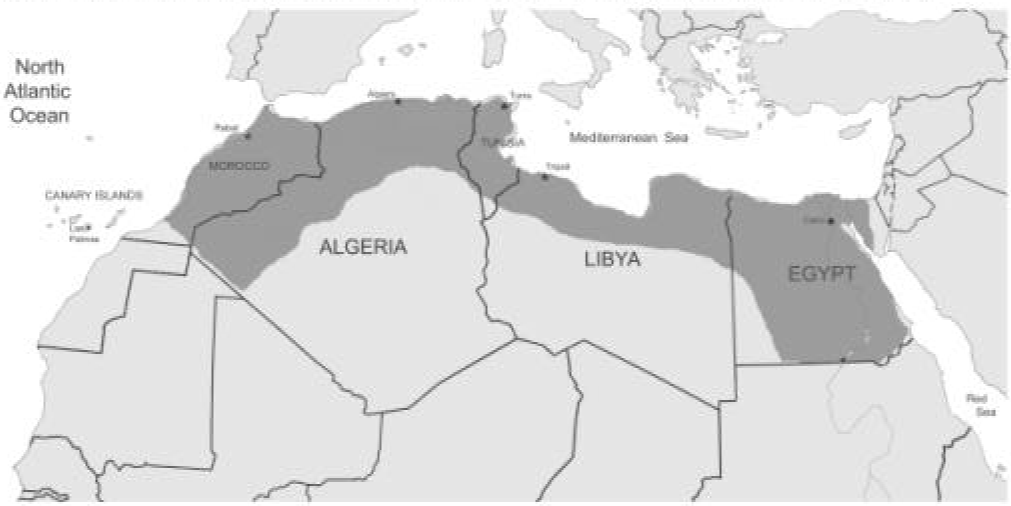
Transmission Cycle(s). The body louse, *P. h. humanus*, is the vector of *B. recurrentis*. After the louse feeds on infective blood, the spirochetes leave the digestive tract and multiply in the insect's body cavity and other organs. They do not invade the salivary glands or the ovaries. Bites and infective feces cannot transmit the pathogen, and transovarial transmission does not occur. Human infection occurs when a louse is crushed and *Borrelia* spirochetes are released. The spirochetes may be scratched into the skin, but there is evidence that *B. recurrentis* can penetrate unbroken skin. Since infection is fatal to the louse, a single louse can infect only one person. However, *B. recurrentis* can survive for some time in a dead louse. Outbreaks of louse-borne relapsing fever require high populations of body lice. Lice leave febrile patients in search of new hosts, and this behavior contributes to the spread of disease during an epidemic.

Humans are the only known reservoir for *B. recurrentis*. Mechanisms of survival during non-epidemic periods are unknown. The life cycle of the body louse is less than two months, and in the absence of transovarial transmission *B. recurrentis* cannot survive in the louse population.

Vector Ecology Profile. Refer to vector profile section under epidemic typhus.

Vector Surveillance and Suppression. Refer to the vector surveillance and suppression section under epidemic typhus

FIG. 5. DISTRIBUTION OF LOUSE-BORNE RELAPSING FEVER IN NORTH AFRICA (DARK SHADING)



F. Relapsing Fever (tick-borne). (Endemic relapsing fever, cave fever)
This is a systemic spirochetal disease characterized by periods of fever alternating with afebrile periods. The number of relapses varies from 1 to 10 or more. The severity of illness decreases with each relapse. The duration of tick-borne relapsing fever is usually longer than the closely related louse-borne relapsing fever. A number of species of *Borrelia* are responsible for the disease. The taxonomy of the pathogen is complex. The close vector-spirochete relationship has led to the definition of most spirochete species by the tick vector. There is great strain variation among tick-borne *Borrelia*, and a single strain can give rise to many serotypes. Some authorities view all species as tick-adapted strains of the louse-borne relapsing fever spirochete, *B. recurrentis*.

Military Impact and Historical Perspective. Although clinical symptoms of tick-borne relapsing fever can be severe, impact on military personnel would be minimal due to low incidence of the disease.

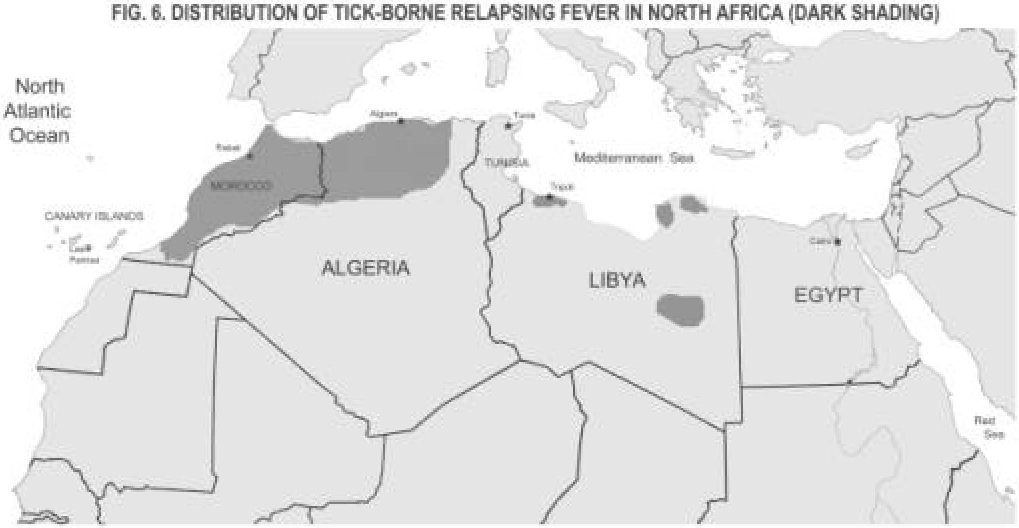
Disease Distribution. Sporadic cases are most often reported from coastal areas and the northern Sahara in Algeria, Libya and Morocco. Sporadic cases have also been recorded from Egypt (Figure 6). Transmission is most likely to occur from April through November. Vector ticks commonly infest caves, bunkers and tombs.

Transmission Cycle(s). Soft ticks of the genus *Ornithodoros* transmit tick-borne relapsing fever. Infection is transmitted from human to human, animal to animal, or from animal to human by the bite of infective ticks. Rodents are sources of infection for ticks, although ticks are more important as a long-term reservoir. In some species of ticks, the pathogen has been maintained naturally for years by transovarial transmission. The rate of transovarial transmission varies greatly among tick species. Ticks of both sexes and all active stages transmit the pathogen by bite or by infectious fluids exuded from pores in the basal leg segments. Spirochetes can pass into bite wounds or penetrate unbroken skin. Exposure to infected blood of patients can cause infections in medical personnel.

Vector Ecology Profiles.
Ornithodoros spp. ticks are the vectors of tick-borne relapsing fever in North Africa. *Ornithodoros erraticus* is the primary vector throughout most of this region. It is widely distributed in both the northern and southern Sinai, throughout the northern tier of other North African countries, and along the Atlantic coast of Morocco. *Ornithodoros savignyi* is a secondary vector and occurs primarily in the northern Sinai of Egypt. *Ornithodoros tholozani*, another secondary vector, has a limited distribution in northeastern Libya.

Ornithodoros savignyi occurs in arid biotopes and tends to live along trails or in the shelter of trees at oases. It feeds primarily on camels and goats but may feed on humans. *Ornithodoros erraticus* often inhabits rodent burrows but will feed on camels, pigs, dogs, donkeys, humans, house rats, and grass rats. *Ornithodoros tholozani* is usually found in caves, huts, cabins, or stables. It feeds on camels, sheep, and, sometimes man. A list of tick species and their distribution is shown in Appendix A.3.

FIG. 6. DISTRIBUTION OF TICK-BORNE RELAPSING FEVER IN NORTH AFRICA (DARK SHADING)



In addition to the habitats mentioned above, these tick species are found in sheltered areas, such as caves, stables, and rock outcroppings. Humans are not a preferred host. Adult *Ornithodoros* spp. ticks feed at night, usually for only 1 to 2 hours. Larvae of *O. erraticus* and *O. tholozani* attach to their hosts for only a short period, usually less than 15 minutes. Larvae of *O. savignyi* remain quiescent and do not feed, molting within a few hours. Subsequent nymphal stages are active and require blood meals in order to develop. Engorgement is rapid, and nymphs drop off their hosts after feeding. Nymphs and adults feed quickly and painlessly, so their bites may go undetected by the human host until well after the tick has detached.

After a variable number of molts, generally 4 to 5, adults emerge and mate. The female mates after feeding and begins to lay eggs. Females may live many years without abloodmeal, but blood is required for egg development. Over the life span of the female the number of eggs deposited may total several hundred, with up to 8 batches of eggs produced.

Vector Surveillance and Suppression. Argasid ticks like *Ornithodoros* are found in the restricted habitats of their hosts and rarely move very far. They occupy loose, dried soil of dwellings, cracks and crevices in mud-walled animal shelters, animal burrows and resting places, and the undersides of tree bark. They can be collected by passing soil through a metal sieve or by blowing a flushing agent into cracks and crevices and other hiding places. Some species are attracted by carbon dioxide, and dry ice can be used in the collection of burrow-dwelling ticks. *Ornithodoros* ticks also fluoresce under ultraviolet light. There is little seasonal fluctuation in numbers of argasids since their microhabitats are relatively stable. **Personal protective measures** (see TIM 36) are the most important means of preventing bites and diseases transmitted by soft ticks. Tents and bedding can be treated with the repellent permethrin. Encampments should not be established in areas infested with *Ornithodoros* ticks. Troops should avoid using indigenous shelters, caves, or old bunkers for bivouac sites or recreational purposes. Control of small mammals around cantonments can eliminate potential vector hosts. Rodent-proofing structures to prevent colonization by rodents and their ectoparasites is an important preventive measure. Limited area application of appropriate acaricides, especially in rodent burrows, can reduce soft tick populations. Medical personnel may elect to administer antibiotic chemoprophylaxis after exposure to tick bites when risk of acquiring infection is high. See Appendix F for **personal protective measures**.

G. Crimean-Congo Hemorrhagic Fever (CCHF).

CCHF is a zoonotic disease caused by a tick-borne virus of the family Bunyaviridae. The disease is characterized by febrile illness with headache, muscle pain and rash, frequently followed by a hemorrhagic state with hepatitis. The mortality rate can exceed 30%. The incubation period ranges from 3 to 10 days. CCHF may be clinically confused with other hemorrhagic infectious diseases.

Military Impact and Historical Perspective. Descriptions of a disease compatible with CCHF can be traced back to antiquity in eastern Europe and Asia. CCHF was first described in soldiers and peasants bitten by ticks of the genus *Hyalomma* while working

and sleeping outdoors on the Crimean peninsula in 1944. The virus was first isolated in 1967. Since there are no available treatment regimens of proven value and recovery from CCHF can be very protracted, military personnel with CCHF would require significant medical resources.

Disease Distribution. CCHF virus is enzootic in the steppe, savanna, semi-desert and foothill environments of eastern and central Europe, Russia, parts of Asia, and throughout Africa. Several Eurasian epidemics have taken a great toll of human life. In recent years, cases of CCHF have tended to be sporadic, with most reported from Bulgaria and South Africa. CCHF is underdiagnosed in many countries due to lack of appropriate medical and laboratory services. In most countries surveyed, the prevalence of human antibodies to CCHF virus in rural areas ranges from 0.1 to 2%. CCHF virus is likely enzootic in widely distributed discrete foci in agricultural areas throughout North Africa. Antibodies to CCHF have been found in limited serosurveys of humans and animals in Egypt, including camels imported to Aswan from Sudan and Kenya. Movement of domestic animals between countries in the region is common and can easily spread the disease. Vector ticks are common on domestic animals throughout North Africa. No human cases have been reported recently. The risk of transmission is highest from June through September.

Transmission Cycle(s). CCHF virus has been isolated from at least 30 species of ticks. From experimental evidence it appears that many species of ticks are capable of transmitting the virus, but members of the genus *Hyalomma* are the most efficient vectors. The aggressive host-seeking behavior of adult hyalommines makes them ideal vectors. The highest prevalence of antibodies in wild and domestic reservoirs has been found in arid areas where *Hyalomma* ticks are common. Antibodies to CCHF virus are widespread in large wild and domestic herbivores. Domestic ruminants generally acquire infection early in life. Viremia in livestock is short-lived and of low intensity. Antibodies or virus have been found in a variety of small mammals, including hares, hedgehogs and rodents. Transovarial transmission of virus in vector ticks is an important reservoir mechanism.

Humans acquire CCHF virus from tick bites, from contamination of broken skin or mucous membranes with crushed tissues or feces of infected ticks, or from contact with blood or other tissues of infected animals. CCHF virus is highly infectious, and nosocomial infection of medical workers has been important in many outbreaks.

CCHF virus loses infectivity shortly after the death of an infected host. There is no indication that consumption of meat processed according to normal health regulations constitutes a hazard.

Vector Ecology Profiles.
Hyalomma anatolicum anatolicum, *H. a. excavatum*, *H. truncatum*, and *H. rufipes* are considered to be the primary human vectors of Crimean Congo hemorrhagic fever. *Hyalomma rufipes* is important in human outbreaks of CCHF because of its wide range of hosts, distribution, and aggressive questing behavior. The degree of other species'

importance in transmission of CCHF virus also depends heavily on host preference. *Boophilus annulatus*, *H. marginatum turanicum*, *Rhipicephalus bursa* and *R. sanguineus* are regarded as possible secondary vectors to humans but are primarily zoonotic vectors. *Hyalomma detritum*, *H. dromedarii*, *H. impeltatum* and *H. m. marginatum* and are also regarded as zoonotic vectors.

Hyalomma a. excavatum and H. a. anatolicum are widely distributed in North Africa. *Hyalomma truncatum* is limited to Egypt, while *H. rufipes* is limited to Egypt and Libya. The secondary vectors discussed above are all widely distributed in North Africa except for *H. m. turanicum*, which is limited to Egypt and Libya. The zoonotic vectors are also widely distributed in North Africa.

Vector ticks, and hence disease, tend to be more rural than urban in distribution. An exception is the brown dog tick, which concentrates in urban areas where canine hosts are more abundant. Information on these vectors is summarized in Appendix B.2. Appendix A.3 lists the distribution of ticks in North Africa.

Tick Bionomics:

General

Female ticks oviposit after leaving the host. The number of eggs laid is variable but runs to thousands in many ixodids. Females die after oviposition. Adult *Hyalomma* wait in rodent burrows or on plants and quickly move toward hosts as they appear. Adult females may remain on the host for 6 to 12 days. Immature ticks generally climb vegetation or other objects in order to quest for hosts. Nymphs remain on the host for 5 to 8 days. Members of the genus *Hyalomma* are among the world's hardiest ticks and can easily survive extremes of heat, cold and aridity for a year or more. However, under ideal conditions, the life cycle can be completed in a year. Over the centuries, hyalommines have dispersed along routes of trading caravans and cattle drives. The life histories of *Hyalomma* ticks are often complex, ranging from one-host to three-host, sometimes even within a single species. Birds are believed to have a role in distributing these ticks.

Specific

Among the primary vectors, *H. a. anatolicum* is one of the most widely distributed tick species in the world. It inhabits steppe, semi-desert, and savanna biotopes. It has dispersed from steppes and semi-deserts primarily along camel and cattle caravan routes. This species is unusual in that all stages may infest a single animal. Cracks in stone or clay walls of stables, courtyards, and feedlots often harbor these ticks. Nymphs tend to feed on the ears of their hosts. The life cycle in hot areas may continue throughout the year. Adult *H. a. anatolicum* prefer to feed on camels, cattle, sheep, goats and dogs but will occasionally feed on humans.

Larvae and nymphs of *H. a. excavatum* nearly always parasitize small mammals. This species tends to remain active even during winter months. Adults of *H. a. excavatum* feed in about equal proportions on cattle and camels and occasionally on humans.

Hyalomma rufipes is basically a savanna species that has extended its range from Sudan into the Nile Valley of Egypt. This species parasitizes large domestic herbivores, warthogs, domestic pets and, occasionally, man. Ground-feeding birds, hares and hedgehogs are hosts of the immature stages. Spring migration of birds is also thought to be an important source of immature ticks brought into Egypt. *Hyalomma truncatum* inhabits floodplains in semi-deserts and steppes, or vegetated hillsides and mountainsides. Adult ticks infest grazing domestic herbivores and, occasionally, humans, while immature stages infest ground-feeding birds and small mammals, including rodents and hares. The bite of this species may cause tick paralysis in sheep and toxicosis in cattle.

Among the secondary vectors, *H. m. turanicum* inhabits steppe and foothill landscapes, particularly along the Mediterranean coast. Adults readily attack cattle as well as humans. Immature stages attack hares, hedgehogs and ground-feeding birds. *Boophilus annulatus*, a one-host tick, is basically a cattle feeder that lives in cattle pens and pastures and only occasionally feeds on man. *Rhipicephalus bursa* is sporadically distributed and prefers grassy areas as well as lightly forested foothills. It occurs in stables and houses where domestic animals rest, or in walls or under stones in outdoor animal feed lots. Immature stages of *R. sanguineus* chiefly parasitize insectivores and rodents. Adults feed on wild and domestic ungulates and dogs.

Among the zoonotic vectors, adults of *H. dromedarii* feed on camels, cattle, goats and dogs. Adults of *H. impeltatum* feed on camels, cattle, sheep and dogs. Adults of *H. detritum* feed on domestic animals in stables or in houses. This species is well adapted to arid areas, such as steppes, banks along floodplains and grassy slopes. Adults of *H. m. marginatum* inhabit steppe, savanna and lightly wooded biotopes. Adults feed on camels, goats, cattle, dogs and, occasionally, humans. All these zoonotic vectors feed primarily on small mammals and birds during their immature stages.

Vector Surveillance and Suppression. Military personnel should conscientiously use **personal protective measures** to prevent tick bites (see TIM 36). Frequent self-examination and removal of ticks is important. Ticks should be handled as little as possible and not crushed. Troops should not sleep, rest or work near rodent burrows, huts, abandoned rural homes, livestock or livestock enclosures. Close contact with livestock and exposure to locally butchered animals should be avoided.

An inactivated mouse-brain vaccine against CCHF has been used in eastern Europe and the former Soviet Union. The FDA has not approved a vaccine for human use. A purified modern vaccine will probably not be developed in view of the limited potential demand.

H. Boutonneuse Fever. (Mediterranean tick fever, Mediterranean spotted fever, Marseilles fever, African tick typhus, Kenya tick typhus, India tick typhus)
This tick-borne typhus is a mild to severe illness lasting a few days to 2 weeks. It is caused by *Rickettsia conorii* and closely related rickettsial organisms. Different strains of *R. conorii* isolated from ticks and humans indicate this pathogen has substantial genetic

and antigenic diversity. The common name of this disease comes from the button -like lesions, 2 to 5 mm in diameter, that develop at tick attachment sites. With antibiotic treatment, fever lasts no more than 2 days. The case fatality rate is very low, even without treatment.

Military Impact and Historical Perspective. Historically boutonneuse fever has not significantly interfered with military operations. Sporadic cases among combat troops can be expected in limited geographic areas. The severity of illness will be dependent upon the strain of *R. conorii* contracted. Because the spotted fevers are regional diseases, military medical personnel newly assigned to an area may be unfamiliar with them and diagnosis may be delayed.

Disease Distribution. Boutonneuse fever is widespread in countries bordering the Mediterranean, and most countries of Africa. Along the European Mediterranean coast, the seroprevalence of boutonneuse fever varies from 4.2 to 45.3% depending on the geographical region. Expansion of the European endemic zone to the north is occurring because North European tourists vacation along the Mediterranean with their dogs, which acquire infected ticks and are then brought home.

Few studies on the epidemiology of rickettsioses in North Africa are available. In countries where laboratories are equipped to study rickettsial diseases, data indicate that the incidence of boutonneuse fever is greater than previously reported. Risk of transmission is highest in suburban coastal areas of Algeria, Libya, Morocco and Tunisia. In Tunisia, 9% of the sera from blood donors tested in 1993 were seropositive for *R. conorii* antibodies. Seroprevalence studies in Morocco during 1992 found 7% of the sera collected from blood donors in Casablanca and 5.6% of the blood donor sera in Fez were positive for antibodies against *R. conorii*. Sporadic cases have been reported from Giza and the Sharqiya and Aswan Governorates in Egypt. Field studies of ticks in the northern Sinai found spotted fever rickettsiae in the hemolymph of 5.4% of *Rhipicephalus sanguineus* ticks removed from dogs and in three species of *Hyalomma* ticks removed from camels. Areas where risk of transmission is highest in North Africa are depicted in Figure 7.

Transmission cycle(s). The disease is maintained in nature by transovarial passage of rickettsiae in ticks, primarily the brown dog tick, *R. sanguineus*, although almost any ixodid tick may harbor the pathogen. Enzootic infection in dogs, rodents and other animals is usually subclinical. Transmission to humans is by bite of infected ticks. Contamination of breaks in the skin or mucous membranes with crushed tissues or feces of infected ticks can also lead to infection.

Vector Ecology Profiles.
Rhipicephalus sanguineus is the principal vector of this disease in the region, and *Haemaphysalis leachii* is a suspected secondary vector.

Rhipicephalus sanguineus, the brown dog tick, is reported throughout the entire region; however, it is more abundant in urban or suburban areas where dogs are common. Close

FIG. 7. ENDEMIC AREAS OF BOUTONNEUSE FEVER IN NORTH AFRICA (DARK SHADING)

association with domestic dogs in endemic areas is a risk factor for boutonneuse fever. *Haemaphysalis leachi* is a suspected vector. This species occurs in Egypt and possibly in coastal areas of northeast Morocco and Algeria. Appendix A.3 lists the known distribution of ticks in North Africa.

Rhipicephalus sanguineus feeds primarily on dogs but also on camels, gerbils and, occasionally, humans. It is a 3-host tick with larvae and nymphs preferring to feed on rats or dogs, while adults feed primarily on dogs and opportunistically on humans. Larvae and nymphs of *R. sanguineus* spend 3 to 6 days feeding on hosts, then drop off to molt. Males feed on hosts for 3 to 5 days, but do not produce sperm until after engorgement. After mating on the host animal, the female feeds for 7 to 15 days, then drops off the host to lay eggs. Females of this species lay hundreds of eggs, generally in the dens of host animals, particularly canines. Eggs may require 10 to 20 days to hatch. Adult *R. sanguineus* are passive in their host-questing activity, rarely moving more than 2 meters to find a host. This species requires a humid microhabitat, which can be found in the dens of its hosts.

Haemaphysalis leachi requires a humid environment. It is a 3-host tick. Larvae and nymphs feed on birds and small mammals (such as hedgehogs and rabbits), while adults feed on deer or livestock, especially cattle. These requirements limit the tick's distribution in North Africa to the comparatively moist, mountainous biotopes of the coastal Atlas Mountains. Attachment times for complete engorgement are up to 5 days for nymphal instars, and up to 20 days for adult females. Males require a blood meal in order to complete spermatogenesis. Females of this species mate on the host and then complete engorgement. Following engorgement, the female drops off the host to lay hundreds of eggs. Eggs require 20 to 30 days to hatch. Nymphs and adults generally quest for hosts from the tips of vegetation.

Vector Surveillance and Suppression. Personal protective measures (see TIM 36) afford the best protection against boutonneuse fever. In endemic areas domestic dogs are commonly infested with the brown dog tick. Troops should not be allowed to feed, befriend or adopt local dogs as pets.

I. Q Fever. (Query fever)

This is an acute, self-limiting, febrile rickettsial disease caused by *Coxiella burnetii.* Onset may be sudden with chills, headache and weakness. Pneumonia is the most serious complication. There is considerable variation in severity and duration of illness. Infections may be inapparent or present as a nonspecific fever of unknown origin. The case fatality rate in untreated acute cases is less than 1%.

Military Impact and Historical Perspective. *Coxiella burnetii* was originally described from Australia in 1937. In ensuing years, *C. burnetii* was found to have a worldwide distribution and a complex ecology and epidemiology. Q fever first appeared among Allied troops in 1944 and 1945, when several sharp outbreaks occurred in the Mediterranean Theater. The disease was not recognized immediately because this rickettsial pathogen had been reported as occurring naturally in humans only in

Queensland, Australia. The need to consider Q fever in the differential diagnosis of primary atypical pneumonia was recognized during this period, but it took several years for this knowledge to become widespread in field military medicine. The British Army in the Mediterranean area experienced several localized epidemics of atypical pneumonia characterized by a high attack rate up to 50% of some units. This was probably Q fever, but no serological proof was ever obtained. Three cases of Q fever were recorded in US military personnel during the Persian Gulf War. Future large-scale military operations in North Africa will probably result in outbreaks of Q fever.

Disease Distribution. *Coxiella burnetii* has been reported from at least 51 countries. Incidence is greater than reported because of the mildness of many cases. Q fever is enzootic throughout North Africa, including the Canary Islands. It is more common in farmers and workers occupationally exposed to livestock. Surveys during the late 1980s and early 1990s in Egypt detected antibodies to *C. burnetii* in 32% of tested individuals in the village of Kafr Ayoub and in 22% of schoolchildren in the area of Bilbeis. Both localities are in Ash Sharqiyah Governorate. A study of sera collected from blood donors in the Suez Canal area, Nile Valley and Nile Delta during 1989 found *C. burnetii* antibodies in 20, 16 and 10%, respectively. Serological surveys of blood donors in Tunisia have detected antibody prevalences as high as 26%. These results implicate *C. burnetii* as a possibly important and under-reported cause of human disease and undiagnosed fevers in North Africa.

Vector Ecology Profiles.
Several species of ixodid ticks transmit *C. burnetii* to animals but are not an important source of human infection.

Transmission Cycle(s). In nature there are two cycles of infection with *C. burnetii*. One involves arthropods, especially ticks, and a variety of wild vertebrates. The other cycle is maintained among domestic animals. Although humans are rarely if ever infected by ticks, arthropods may transmit infection to domestic animals, especially sheep and cattle. Domestic animals have inapparent infections but shed large quantities of infectious organisms in their urine, milk, feces, and especially their placental products. Because *C. burnetii* is highly resistant to desiccation, light and extremes of temperature, infectious organisms become aerosolized, causing widespread outbreaks in humans and other animals, often at a great distance from the place of origin. Dust in sheep or cattle sheds may become heavily contaminated. Once established, animal-to-animal spread of *C. burnetii* is maintained primarily through airborne transmission. Outbreaks of Q fever in humans have been traced to consumption of infected dairy products and contact with contaminated wool or hides, infected straw, and infected animal feces. *Coxiella burnetii* may enter through minor abrasions of the skin or the mucous membranes. Although rare, human-to-human transmission of Q fever has occurred.

Vector Surveillance and Suppression. A satisfactory vaccine has not been developed, and human vaccination has been hampered by the high rate of adverse reactions. Measures to identify and decontaminate infected areas and to vaccinate domestic animals are difficult, expensive and impractical. Military personnel should avoid consumption of

local dairy products and contact with domestic animals, hides, and carcasses of dead animals. This is militarily significant as learned during the Persian Gulf War where troops had frequent exposure to domestic animals and animal carcasses. Soldiers should not rest, sleep, or work in animal sheds or other areas where livestock have been housed.

J. Murine Typhus. (Flea-borne typhus, Endemic typhus, Shop typhus)
The infectious agent, *Rickettsia typhi*, causes a milder disease than does *R. prowazekii*, but it still results in a debilitating illness with high fever. The incubation period ranges from 1 to 2 weeks, and clinical symptoms may last up to 2 weeks in untreated cases. Mortality is very low, and serious complications are infrequent. The disease is easily treated with antibiotics. Absence of louse infestation, seasonal distribution, and the sporadic occurrence of murine typhus help to differentiate it from epidemic typhus.

Military Impact and Historical Perspective. Confusion in diagnosis between murine typhus and closely related diseases may occur. Prior to World War II, murine typhus was not distinguished from the epidemic form, and its importance in prior wars is unknown. During World War II, there were 786 cases in the US Army with 15 deaths. Only about a dozen cases were recorded in the Mediterranean theater. There are little available data on the incidence of murine typhus during military operations in Korea or Vietnam. During the Vietnam War, murine typhus was concentrated in port cities and incidence seemed low. However, retrospective studies indicated that a large proportion of fevers of unknown origin experienced by Americans during that conflict were due to *R. typhi*. The disease is most common in lower socioeconomic classes and increases when disruptions by war or mass migrations force people to live in unsanitary conditions in close association with domestic rodents. However, murine typhus has not been a major contributor to disease rates in disaster situations. Because of the sporadic incidence of murine typhus, it is difficult to confidently predict the potential impact of this disease on future military operations, although its military impact would probably be minimal.

Disease Distribution. Murine typhus occurs worldwide, and sporadic cases have been reported throughout North Africa. Human cases occur principally in urban areas where commensal rodent infestations are common, although infected rodents have been collected from rural villages. Outbreaks have been reported from Algeria (especially in extreme northeastern areas), Libya, Morocco and Tunisia. Antibodies against *R. typhi* were found in 3.6% of the sera from blood donors in a 1993 study in Tunisia. Murine typhus is widespread in Egypt. Recognized foci occur in the Nile Delta, Nile Valley, northeastern Sinai Peninsula, and along the Suez Canal. Urban foci include Alexandria, Cairo, Al Isma'iliyah, Port Said and most other port cities. Surveys during the early 1990s detected *R. typhi* antibodies in 58% of tested individuals in the village of Kafr Ayoub and 53% of schoolchildren surveyed in the area of Belbeis. Both areas are in the Ash Sharqiyah Governorate. Prevalence of *R. typhi* antibodies was higher in people with occupational exposure to rodents. Fifty-nine percent of the garbage collectors and rodent control workers in Cairo were seropositive. The areas at greatest risk of transmission are depicted in Figure 8.

FIG. 8. DISTRIBUTION OF MURINE TYPHUS IN NORTH AFRICA (DARK SHADING)

Transmission Cycle(s). Murine typhus is a zoonotic infection associated with domestic rats (*Rattus rattus* and *R. norvegicus*) and vectored by their fleas and the spiny rat louse, *Polyplax spinulosa*. The Oriental rat flea, *X. cheopis*, is the most important vector. Neither rodents nor their ectoparasites are affected by infection with *R. typhi*. Inoculating crushed fleas or infective flea feces into the skin at the bite site transmits murine typhus. Scratching due to the irritation of fleabites increases the likelihood of infection. *Rickettsia typhi* is rarely transmitted directly by fleabite. Other routes of infection are by inhalation of dry flea feces containing rickettsiae that may remain infective for months, and ingestion of food contaminated by rodent urine. Murine typhus is not transmitted from person to person. The risk of transmission is considered seasonal during the warm months of May to October in northern areas of Algeria, Libya, Tunisia and Morocco. In Egypt, the risk is extended from April through November.

Vector Ecology Profiles.
The primary vector is the Oriental rat flea, *X. cheopis*. Cat and dog fleas, *Ctenocephalides felis* and *C. canis*, as well as the body louse, *Pediculus h. humanus*, are potential secondary vectors for humans. However, these vectors have not been incriminated in epidemics in this region. The northern rat flea, *Nosopsyllus fasciatus*, spiny rat louse, *Polyplax spinulosa*, and tropical rat mite, *Ornithonyssus bacoti*, are vectors that maintain the enzootic cycle of the disease. Fleas and their distribution in North Africa are listed in Appendix A.4.

Polyplax spinulosa, the spiny rat louse, remains in close association with its rodent hosts. Female lice attach eggs to rodent hairs and all developmental stages live exclusively on rodents. Lice are only transferred from rodent to rodent by body contact. These lice feed on rat blood but do not feed on humans.

Ornithonyssus bacoti, the tropical rat mite, lives on commensal and other rodents throughout the region and feeds on blood and other fluids that ooze from the tiny bite wounds. Engorged females start laying eggs within 2 days after feeding, and continue to lay groups of eggs for 2 to 3 days. Eggs hatch in 1 to 2 days and develop into larvae, then protonymphs, and then deutonymphs. The entire life cycle, through the adult stage, requires only 5 to 6 days. These mites will readily infest humans if their rodent hosts are suddenly eliminated, or if humans live in close association with rodent nests.

The Oriental rat flea, *Xenopsylla cheopis*, occurs mostly in urban and periurban areas, in conjunction with its rodent hosts. However, it may occur sporadically in villages, when rats are present, or in highlands, associated with gerbils. The distribution of the Oriental rat flea is limited by the distribution of its hosts especially *Rattus rattus alexandrinus*, *R. r. frugivorous*, *R. norvegicus*, *Mus musculus* (house mouse), and *Gerbillus* spp. (gerbils). The zoonotic vectors *O. bacoti* and *P. spinulosa* have similar distributions. *Xenopsylla cheopis* has been reported from the northern coasts and inland areas of Morocco, Algeria, and Libya. It is also widely distributed throughout the Nile Valley, along the northern coast of Egypt and in Egyptian cities.

The northern rat flea, *Nosopsyllus fasciatus*, though distributed widely in North Africa, is not as abundant as it is in many other parts of the world. It occurs primarily where commensal rodents are found, particularly *R. norvegicus* and *R. rattus.* These rodents are widely distributed in urban settings throughout the region, particularly in the port cities of Morocco, Algeria, Tunisia, Libya and Egypt. In Egypt, the Oriental rat flea is widely distributed in the Nile Delta, along the Nile River and along the Suez Canal. The biology of flea vectors is discussed in the section on plague.

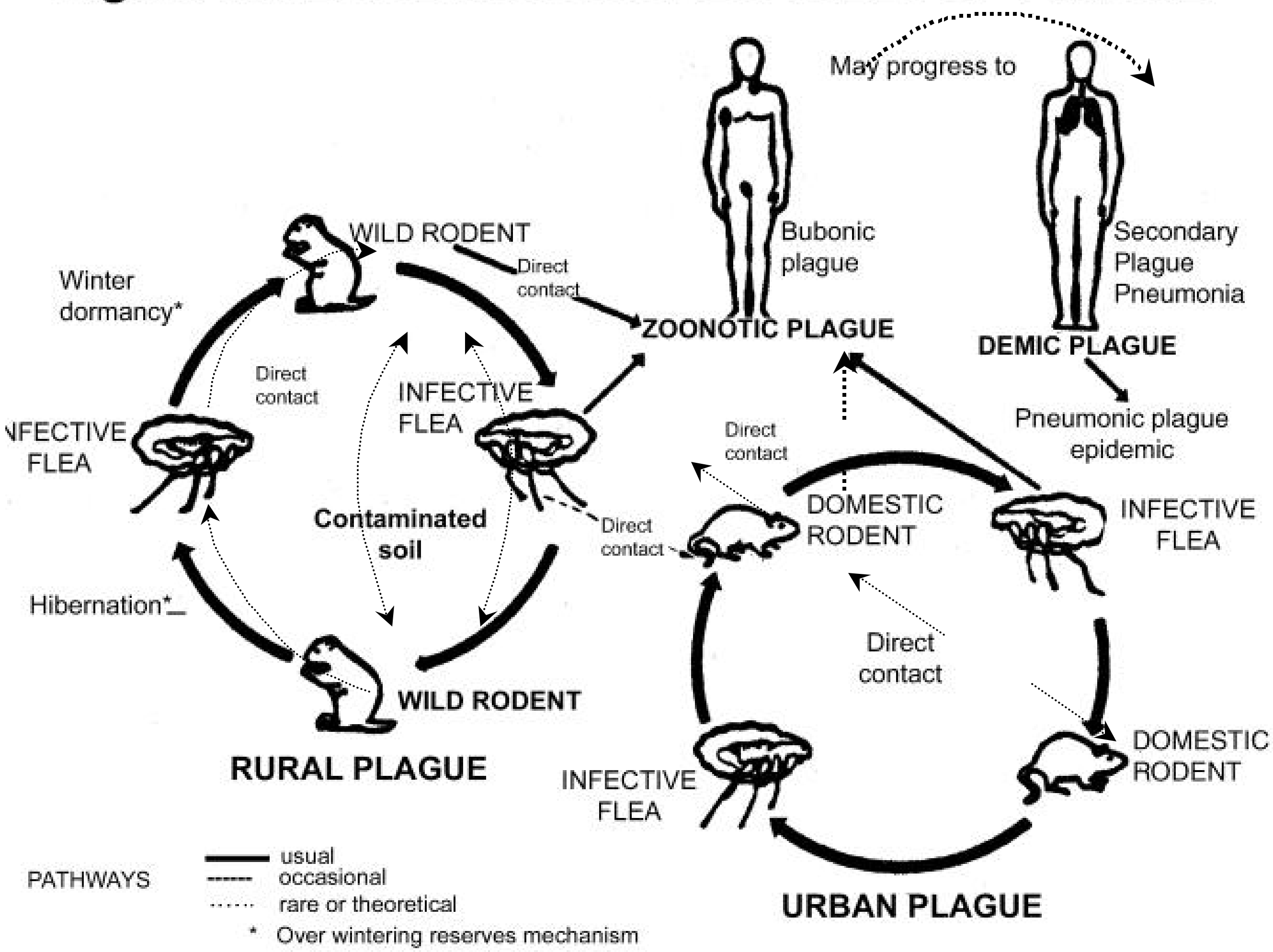
Vector Surveillance and Suppression. Methods of surveillance for rodent ectoparasites are discussed in the following section on plague. Rodent control is thoroughly discussed in Technical Guide (TG) 138, Guide to Commensal Rodent Control. Insecticides recommended for flea control are listed in TIM 24, Contingency Pest Management Pocket Guide.

K. Plague. (Pestis, Black death)
Plague is a zoonotic bacterial disease involving rodents and their fleas, some species of which occasionally transmit the infection to man and other animals. The infectious agent, *Yersinia pestis*, causes fever, chills, myalgia, nausea, sore throat and headache. Bacteria accumulate and swelling develops in the lymph nodes closest to the infected bite. Since most fleabites occur on the lower extremities, the nodes in the inguinal region are involved in 90 percent of cases. The term bubonic plague is derived from the swollen and tender buboes that develop. Plague is most easily treated with antibiotics in the early stages of the disease. However, untreated bubonic plague has a fatality rate of 50%. Infection may progress to septicemic plague, with dissemination of the bacteria in the bloodstream to diverse parts of the body. Secondary involvement of the lungs results in pneumonia. Pneumonic plague is of special medical significance since respiratory aerosols may serve as a source of person-to-person transmission. This can result in devastating epidemics in densely populated areas. Untreated pneumonic or septicemic plague is invariably fatal but responds to early antibiotic therapy. To ensure proper diagnosis, medical personnel should be aware of areas where the disease is enzootic. Plague is often misdiagnosed, especially when travelers or military personnel develop symptoms after returning from an enzootic area.

Military Impact and Historical Perspective. Epidemics of plague have been known since ancient times and have profoundly affected civilization. During the Middle Ages, Europe experienced repeated pandemics of plague. Twenty-five percent of the continent's population died during the great pandemic of the 14th century. The last pandemic originated at the close of the 19th century in northern China and spread to other continents by way of rats on steamships. Plague has been a decisive factor affecting military campaigns, weakening besieged cities or attacking armies during the Middle Ages. Severe ecological disturbances and dislocations of human populations during the Vietnam War led to outbreaks of plague. Even though plague has been declining on a worldwide basis, persistent enzootic foci can trigger the recurrence of epidemics when war or natural disaster disrupts general sanitation and health services. Presently, the threat of plague to military operations is low.

FIG. 9. ENDEMIC FOCUS OF PLAGUE IN NORTH AFRICA (DARK SHADING)

Figure 10. EPIDEMIOLOGICAL CYCLES OF PLAGUE



Disease Distribution. Current enzootic foci of plague in North Africa are unclear. Historically, outbreaks have occurred in urban areas and port cities of Egypt. The most recent outbreak was reported in 1984 from the northeastern coast of Libya. Eight cases were reported from two previously known foci near the city of Tobruk, Darnah Municipality. The risk of plague in North Africa should be considered low. Areas of enzootic plague are depicted in Figure 9.

Transmission Cycle(s). Plague is a disease of rodents. It is maintained in nature among wild rodents and their fleas (Figure 10). This zoonotic cycle is termed sylvatic, campestral, rural, or wild plague and can be very complex, involving many rodent and flea species. Worldwide, over 220 species of rodents have been shown to harbor *Y. pestis*. Gerbils are important rodent reservoirs in North Africa. In addition, the camel and goat are susceptible to infection with plague bacteria and may have a significant role in the dissemination of human plague when infected animals are butchered for human consumption.

Some rodents are highly susceptible to infection, resulting in high mortality. Although large numbers of dead and dying rodents are a good indication of an epizootic of plague, rodent species that are resistant to infection are more important in maintaining the zoonotic cycle. Most cases in military personnel would probably occur as a result of intrusion into the zoonotic cycle during or following an epizootic of plague in wild rodents. Domestic cats and dogs may carry infected rodent fleas into buildings or tents. Cats may occasionally transmit infection by their bites or scratches, or by aerosol when they have pneumonic plague. Troops should not be allowed to adopt cats or dogs as pets during military operations.

The entry of wild rodents or their infected fleas into human habitations can initiate an epizootic among commensal rodents, primarily *Rattus* spp., which are highly susceptible to infection. Close association of humans and large populations of infected commensal rodents can result in an urban cycle of plague. A similar cycle can occur in military cantonments experiencing large infestations of commensal rodents. The most important vector of urban plague worldwide is the Oriental rat flea, *Xenopsylla cheopis*. The northern rat flea, *Nosopsyllus fasciatus*, and the human flea, *Pulex irritans*, are secondary vectors. A complete list of North African flea species and their distribution appears in Appendix A.4.

Plague is transmitted to humans primarily by the bite of infected fleas. Fleas often exhibit a host preference, but most species of medical importance readily pass from one host to another. A lack of absolute host specificity increases the potential for infection and transmission of pathogens. Plague may also be acquired by handling tissues of infected animals or humans, and by person-to-person transmission of pneumonic plague. Crushed infected fleas and flea feces inoculated into skin abrasions or mucous membranes can also cause infection. Not all flea species are competent vectors. The vector competence of the Oriental rat flea is attributed to enzymes produced by the plague bacilli that cause blood to coagulate in the flea's digestive tract. The flea attempts to clear the blockage in its digestive tract by repeated efforts to feed. In the process,

plague bacilli are inoculated into the host. Fleas may remain infective for months when temperature and humidity are favorable. *Xenopsylla cheopis* may require 2 to 3 weeks after an infective blood meal before it can transmit plague bacilli.

Vector Ecology Profiles.
Xenopsylla cheopis occurs mostly in urban areas, in association with its rodent hosts. However, it may occur sporadically in villages, when rats are present, or in highlands, associated with gerbils. The distribution of the Oriental rat flea is determined by the distribution of its hosts, primarily *R. rattus*, *R. norvegicus*, *Mus musculus*, *Meriones* spp. (jirds) and *Psammomys* spp. (fat sand rats).

Adult fleas feed exclusively on blood and utilize blood protein for egg production. After feeding on a rodent, the female Oriental rat flea lays several eggs (2 to 15). Several hundred eggs may be laid during the entire life span. Oviposition most often occurs on the hairs of the host, although the eggs drop off and hatch in the nest or its environs. In locally humid environments, such as rodent burrows, eggs may hatch in as little as two days. Larvae grow rapidly when temperature and humidity are above 25°C and 70% r.h., living in the nest and feeding on dried blood, dander, and variety of organic material. The larval stages can be completed in as little as 14 days (at 30 to 32 °C), or as long as 200 days when temperatures drop below 15°C or when nutrition is inadequate. Mature larvae pupate in cocoons, loosely attached to nesting material. Adult emergence may occur in as little as 7 days or as long as a year and is stimulated by carbon dioxide or host activity near the cocoon. Adult fleas normally await the approach of a host rather than actively search for one. Fleas feed on humans when people and rodents live close together, but man is not a preferred host. However, if rat populations decline suddenly due to disease or rat control programs, these fleas readily switch to feeding on humans. The life span of adult *X. cheopis* is relatively short compared to that of other flea species, often less than 40 days. Flea populations increase rapidly during periods of warm, moist weather.

The northern rat flea, *Nosopsyllus fasciatus*, has a life cycle similar to that of other fleas. *N. fasciatus* lays its eggs in the nests or burrows of commensal rodents. Larvae have the unique habit of attaching to the abdomen of an adult flea and ingesting fecal blood as it passes from the anus of the adult. Adults of this species rarely feed on man. *N. fasciatus* prefers cooler temperatures than *X. cheopis*. Under favorable conditions, the adult life span is just under 100 days.

The life cycle of *Pulex irritans*, the so-called human flea, is similar to that of the Oriental rat flea. This species has a low to moderate preference for feeding on humans but aids in enzootic maintenance of plague among rats, mice, and gerbils. *Pulex irritans* appears to prefer pigs, but in the absence of other hosts, this flea readily feeds on humans. Domestic animals such as dogs are also suitable hosts. Adults of both *N. fasciatus* and *P. irritans* can survive unfed for several months.

Vector Surveillance and Suppression. The methods of flea surveillance depend upon the species of flea, the host, the ecological situation, and the objective of the

investigation. Fleas can be collected from hosts or their habitat. The relationship of host density to flea density should be considered in assessing flea populations. It has been common practice for years to use a flea index (average number of fleas per host), especially in studies of rodent fleas. For *X. cheopis*, a flea index of > 1.0 flea per host is considered high. The flea index has many limitations, since only adults are considered and then only while they are on the host. Fleas are recovered by combing or brushing the host or by running a stream of carbon dioxide through the fur while holding the host over a white surface.

Flea abundance in the environment can be determined by counting the number of fleas landing or crawling in one minute on the lower parts of the legs of the observer. The trouser legs should be tucked into the socks to prevent bites. Flea populations can also be estimated by placing a white cloth on the floor in buildings or on the ground in rodent habitat and counting the fleas that jump onto the cloth. Various flea traps have been devised. Some use light or carbon dioxide as an attractant. Sifting and flotation of rodent nesting materials or of dust and debris from infested buildings are effective methods of collecting fleas from the environment.

Serologies of wild carnivores are sensitive indicators of enzootic plague. Fleas and tissues from suspected reservoirs or humans may be submitted for plague analysis to the Centers for Disease Control and Prevention, National Center for Infectious Diseases, Division of Vector-borne Infectious Diseases, P.O. Box 2087, Foothills Campus, Fort Collins, Colorado 80522. Blood samples are easily collected on Nabuto ® paper strips, dried and submitted to a laboratory for testing. Consult TG 103, Prevention and Control of Plague.

Control of enzootic plague over large areas is not feasible. Control efforts should be limited to foci adjacent to urban areas, military encampments, or other areas frequented by military personnel. If possible, cantonment sites should not be located in wild rodent habitat. Fleas quickly leave the bodies of dead or dying rodents in search of new hosts. Consequently, flea control must always precede or coincide with rodent control operations. Application of insecticidal dusts to rodent burrows is effective in reducing flea populations, but it is very labor intensive. Fleas can be controlled by attracting infested rodents to bait stations. The stations contain an insecticidal dust that rodents pick up while feeding, or a rodent bait containing a systemic insecticide that fleas ingest when taking a bloodmeal. Baiting with systemic formulations may pose environmental risks.

Urban plague control requires that rodent runs, harborages and burrows be dusted with an insecticide labeled for flea control and known to be effective against local fleas. Insecticide bait stations can also be used. Rat populations should be suppressed by well-planned and intensive campaigns of poisoning and concurrent measures to reduce rat harborages and food sources. Buildings should be rat-proofed to the extent possible to prevent rats from gaining entry. Domestic rodent control is discussed in Technical Guide (TG) 138, Guide to Commensal Rodent Control. Insecticides recommended for flea control are listed in TIM 24, Contingency Pest Management Pocket Guide.

Military personnel, especially those involved in rodent control, should use the **personal protective measures** discussed in TIM 36, Personal Protective Techniques Against Insects and Other Arthropods of Military Significance, and outlined in Appendix F. Active immunization with a vaccine of killed bacteria confers protection against bubonic plague (but not pneumonic plague) in most recipients for several months. Booster injections are necessary every six months. The efficacy of plague vaccine in humans has not been demonstrated in a controlled trial, so vaccination should not be relied upon as the sole preventive measure.

L. Rift Valley Fever.
A Phlebovirus of the family Bunyaviridae causes rift Valley fever (RVF). Humans infected with RVF typically have either no symptoms or a mild illness associated with fever and liver abnormalities. However, in some patients the illness can progress to hemorrhagic fever with shock or hemorrhage, encephalitis with coma or seizures, and/or ocular disease. Patients who become ill usually experience fever, generalized weakness, back pain, dizziness and weight loss at onset of fever. Typically, patients recover within one week after onset of illness. The most common complication associated with RVF is inflammation of the retina resulting in permanent vision loss in 1 to 10% of affected patients. Approximately 1% of patients die of the disease, but case-fatality rates are significantly higher for infected animals. Nearly 100% of pregnant livestock infected with RVF virus abort their fetuses. There is no established course of treatment for infected patients, although some antiviral drugs such as ribavirin show promise.

Military Impact and Historical Perspective. Veterinary officers in Kenya first reported RVF among livestock in the early 1900s, although the virus wasn't isolated until 1930. The most notable epizootic occurred in South Africa during 1950 to1951 and was estimated to have caused the death of 100,000 sheep and cattle and to have involved 20,000 human cases. A major epizootic occurred in Kenya at the same time. In 1977 the virus was detected in Egypt and caused a large outbreak among animals and humans. The first epidemic of RVF in West Africa was reported in 1987 and was linked to the Lower Senegal River Project. The project caused flooding in the lower Senegal River area that produced large populations of mosquitoes.

During epizootics, RVF could seriously affect military operations. Five percent of Swedish United Nations Emergency Forces soldiers serving in Egypt and the Sinai peninsula were infected with RVF virus during the 1977-78 epidemic in Egypt. Medical personnel should be aware of clinical and diagnostic procedures to differentiate RVF from other fevers with similar clinical syndromes.

Disease Distribution. RVF is generally found in regions of eastern and southern Africa where sheep and cattle are raised. However, RVF virus also exists in most countries of sub-Saharan Africa and Madagascar. Outbreaks have previously been reported in Cameroon, Central African Republic, Mali, Mauritania, Mozambique, Nigeria, Senegal, South Africa, Sudan, Tanzania, Zambia and Zimbabwe. The 1977-1978 epidemic of

RVF in Egypt was the first report of the virus outside sub -Saharan Africa. That epidemic was associated with over 18,000 cases and 598 deaths in humans. Retrospective serosurveys have indicated the RVF virus was not present in Egypt before the 1977 epidemic. RVF virus was probably introduced into Egypt by infected sheep transported from northern Sudan where RVF was epizootic.

Another epidemic occurred in May 1993 in the Aswan Governorate of southern Egypt, and by August it had spread to the Nile Delta. The outbreak eventually affected persons residing in the governorates of Dakhla, Damietta, Gharbiya, Giza, Ism ailiya, Kafr al-Dheikh, Minufiya, Port Said, Qena and Sharkiya. A large outbreak of RVF was reported early in 1998 in northeastern Kenya and southern Somalia following exceptionally heavy rains. The outbreak spread to Kenya's Eastern, Rift Valley and Coa st provinces, which include some national parks. As many as 300 persons in Kenya and an unknown number in Somalia died.

The current enzootic status of RVF in North Africa is unclear. Active foci of RVF in neighboring countries of sub-Saharan Africa, abundant vector populations in North African countries, and the international movement of domestic animals increase the likelihood of future outbreaks of RVF in North Africa.

Transmission Cycle(s). RVF primarily affects domestic animals such as cattle, buff alo, sheep, goats and camels. High viremias occur in infected humans. Thus, humans, as well as domestic animals, could be a source of virus to infect potential vectors. Mosquitoes transmit RVF virus. Unlike most arboviruses that are associated with eit her a single species or closely related group of mosquitoes, RVF virus has been isolated from at least 28 species in six genera of mosquitoes. Epizootics have generally occurred during years of excessive rainfall and localized flooding that produced large populations of mosquitoes. RVF virus may be transmitted by other blood-sucking arthropods. Isolations of RVF virus have been made from *Culicoides* spp. in Kenya and Nigeria, but there is some doubt whether *Culicoides* or other insects vector the virus. *Culex pipiens pipiens* was implicated as the principal vector during the 1977-78 epidemic in Egypt. Laboratory studies have shown *Aedes caspius*, *Culex perexiguus* and *Cx. antennatus* are competent vectors. Vector competence studies and knowledge of mosquito density and feeding behavior in areas where RVF virus infections have occurred suggest that these species may be the principal vectors involved in domestic animal transmission and as bridge vectors from domestic animals to humans. In contrast, *Cx. p. pipiens* appears to be the principal vector for human-to-human transmission. Transovarial transmission of the virus is known to occur in some mosquito species.

Humans can also acquire infection if they are exposed to the blood or other body fluids of infected animals. This exposure can result from the slaughtering or handling of infected animals or by touching contaminated meat during the preparation of food. Abattoir workers are a useful sentinel population for surveillance of RVF virus. Laboratory infection through aerosol transmission of RVF virus has resulted from exposure to specimens containing the virus.

Vector Ecology Profiles.
Culex p. pipiens is the most common vector species and is also the most anthropophilic of the suspected mosquito vectors. *Culex univitattus*, *Cx. antennatus* and *Cx. perexiguus* are also vectors but are more zoophilic and less abundant than *Cx. p. pipiens*; they are therefore considered more important in the zoonotic cycle of the disease. *Aedes caspius* is a suspected zoonotic vector.

Culex p. pipiens breeds year-round in southern Egypt along the Nile River and its tributaries and from May to October in the Nile Delta. It is the most abundant mosquito in these areas. This species prefers birds and domestic mammals as hosts but readily attacks humans. It feeds indoors and outdoors and frequently rests indoors, especially during winter months. Adults feed early in the evening, usually within 2 hours of sunset, and are strong fliers that may travel 3 to 5 km for a blood meal. *Culex p. pipiens* deposits egg rafts, containing 75 to 200 eggs each, on the water surface 3 to 4 days following a bloodmeal. Eggs hatch 2 to 4 days after deposition. Common oviposition sites include cisterns, water troughs, irrigation spillovers, wastewater lagoons, septic tank seepages, and swamps. Larvae of the *Cx. pipiens* complex generally prefer ground pools with high concentrations of organic matter or swamps with emergent vegetation. Polluted water from septic systems is an ideal breeding site for *Cx. p. pipiens*. Larval development requires 7 to 9 days in a temperature range of 25 to 30 °C. At lower temperatures, larval stages may require 15 to 20 days. The pupal stage lasts about 2 days. Adult populations display two peaks in Egypt, one in May, and another from September to October. In southern Egypt, populations of this mosquito occur year-round because wastewater is available most of the year. Increasing urbanization and poor sewage systems in many parts of North Africa contribute to the spread and abundance of *Cx. p. pipiens*. In some areas along the Nile, human biting rates by *Cx. p. pipiens* may exceed 10,000 per person per year.

Culex univittatus breeds year-round in southern Egypt, but in the Nile Delta it is abundant only from May to October. Population peaks occur in May and again in September to October. It feeds indoors and outdoors but rests primarily outdoors. It is a zoophilic species preferring birds and domestic animals to man. Adults are strong fliers, traveling up to 5 km to obtain a bloodmeal. This species is very long-lived, which increases its importance as a vector. Larval breeding sites include drains, irrigation seepages, flooded rice fields, swamps, slow-moving streams, or ground pools with either high organic content or dense vegetation. Although *Cx. univittatus* lives in pools with high organic content, it prefers relatively clean water compared to *Cx. pipiens* and is much more dependent on rainfall in order to propagate in large numbers. The life cycle is similar to that of *Cx. pipiens*, as described above.

C*ulex antennatus* breeds year-round in southern Egypt, but in the Nile Delta it is abundant only from May to October. There are two population peaks in northern Egypt, one in May and another in September to October. *Culex antennatus* is a zoophilic species, preferring sheep, goats, and horses to humans. It also is much more exophagic and exophilic than *Cx. p. pipiens*. Consequently, it is primarily considered an enzootic vector. Adults are strong fliers, capable of traveling 5 km to find a bloodmeal. Larvae of

this species breed in sunlit, grassy ponds or pools with relatively clear, clean water. Rice fields, irrigation ditches, and isolated stream pools are the most common habitats reported for this species in North Africa. The life history is similar to that of *Cx. p. pipiens*.

The biology of *Cx. perexiguus* is also similar to that of *Cx. pipiens*. In Egypt, this species breeds in standing ground pools, irrigation plots and rice fields. *Culex perexiguus* feeds and rests primarily outdoors. The biology of *Ae. caspius* is discussed under dengue.

Vector Surveillance and Suppression. Mosquito surveillance and control measures as outlined in the section on malaria can be effective in reducing transmission of RVF virus during an epizootic. The use of **personal protective measures** (see TIM 36) is the best means of disease prevention. Troops should not sleep outdoors at night and should avoid exposure to blood or tissues of animals potentially infected with RVF virus. Precautions during the handling of blood, blood products, medical instruments, or syringes should minimize the risk of disease among workers in health facilities or laboratories. Vaccines for veterinary use are available, but they cause birth defects and abortions in sheep and induce only low-level protection in cattle. Experimental human vaccines have demonstrated promising results in laboratory studies but are not currently approved for use against RVF.

M. West Nile Fever.

West Nile fever is a mosquito-borne illness characterized by fever, headache, muscular pain, and rash. Occasionally, serious complications involve the liver and nervous system. The etiological agent, West Nile virus (WNV), is named after the district of Uganda where the virus was first isolated. It is a *Flavivirus* closely related to viruses causing Japanese encephalitis and St. Louis encephalitis. Infection with WNV is most often asymptomatic. The incubation period ranges from 1 to 6 days and clinically resembles a mild dengue-like illness.

Military Impact and Historical Perspective. WNV was isolated in 1937 and was one of the earliest human arboviral infections to be documented. Undoubtedly, WNV has been the cause of many cases classified as fevers of unknown origin in military personnel. In view of the mild illness and the infrequent occurrence of epidemics, the military impact of this virus would be minor, particularly in comparison with other diseases in the Middle East. Infection with WNV will complicate diagnoses by medical personnel, since West Nile fever cannot be clinically distinguished from many other arboviral fevers.

Disease Distribution. WNV has been isolated in many areas of Africa, Europe, India and Pakistan. Viral isolations from vertebrate hosts and mosquitoes, and serological surveys of humans and suspected reservoir hosts indicate WNV is circulating in Egypt, Morocco and Tunisia and is probably enzootic in other areas of North Africa. West Nile fever is common in the Nile River Delta and Nile Valley, with the risk of transmission increasing from north to south. Surveys in the Nile River Delta during 1991 found 20% of tested individuals seropositive for WNV.

Transmission Cycle(s). WNV has been isolated from numerous wild birds and mammals. Serological surveys have demonstrated WNV antibodies in wild and domestic bird species, wild mammals such as lemurs, rodents and bats, and domestic animals such as camels, horses, mules, donkeys, goats, cattle, water buffalo, sheep, pigs and dogs. However, birds are considered to be the primary reservoir for WNV and may reintroduce the virus during seasonal migrations. Infections in most mammals fail to produce viremias high enough to infect potential vectors. WNV has been isolated from several species of mosquitoes in nature, especially *Culex* spp. which are recognized as the major vectors. WNV has also been recovered from bird-feeding ticks and mites. A natural bird-tick zoonotic cycle has been suggested, but the role of ticks in the natural transmission of WNV has not been well defined. Mosquitoes are clearly implicated in the transmission of WNV to humans. WNV replicates quickly in mosquitoes when temperatures exceed 25^{o}C. Infected mosquitoes can transmit WNV for life.

Vector Ecology Profiles.
Culex univittatus is the primary vector. *Culex antennatus*, *Cx. pipiens pipiens* and *Cx. perexiguus* are potential vectors. The bionomics of these species are discussed under Rift Valley Fever.

Culex p. pipiens usually prefers to feed on birds but readily feeds on humans and large animals like camels, cattle and goats. This species is an annoying biter and produces a high-pitched buzzing sound that can easily be heard. Members of the *Cx. pipiens* complex feed and rest indoors or outdoors. Three or 4 days after a bloodmeal, *Cx. p. pipiens* deposits egg rafts containing 75 to 200 eggs on the water surface. However, *Cx. p. molestus* is autogenous and does not require a bloodmeal prior to oviposition. Common oviposition sites include cisterns, water troughs, irrigation spillovers, wastewater lagoons, and swamps. Eggs hatch 2 to 4 days after deposition. Larvae of the *Cx. pipiens* complex generally prefer ground pools with high concentrations of organic matter or swamps with emergent vegetation. Polluted water from septic systems is an ideal breeding site for this complex. Larval development requires 7 to 9 days at a temperature range of 25 to 30°C. At lower temperatures, larval stages may require 15 to 20 days. The pupal stage lasts about 2 days. Adult populations display two small population peaks in temperate countries, one from May to June, and another from September to October. However, since members of the *Cx. pipiens* complex frequently breed in various types of wastewater, the peaks are not as sharp as for other *Culex* species. Increasing urbanization and poor sewage systems in many areas of North Africa contribute to the spread and abundance of *Cx. p. pipiens*.

Culex univittatus breeds in swamps, slow-moving streams, or ground pools with either high organic content or dense vegetation. The life cycle is similar to that of the *Cx. pipiens* complex. Although *Cx. univittatus* tolerates organic matter, it prefers relatively clean water compared to the *Cx. pipiens* complex and is much more dependent on rainfall in order to propagate in large numbers. *Culex univittatus* also prefers birds but bites man readily during its peak population periods. In contrast to the *Cx. pipiens* complex, *Cx. univittatus* is less likely to feed indoors.

Culex perexiguus breeds in standing ground pools, irrigation plots, date palm plots, and rice fields. It prefers breeding sites with vegetation and sunlight. *Culex antennatus* breeds in sunlit grassy ponds with relatively clear, clean water. Rice fields and isolated stream pools are the most common habitats reported for this species. *Culex antennatus* and *Cx. perexiguus* feed and rest primarily outdoors. All these *Culex* species generally begin biting at dusk and continue throughout the night with peak biting occurring the first hours after sunset.

Vector Surveillance and Suppression. Epidemics of West Nile fever are infrequent, and public health officials in North African countries can rarely justify continued long-term surveillance for virus activity when considering other health care demands. Reduction of mosquito populations by ULV spraying may be useful as a means of disease control. The most feasible long-term control strategies involve reducing vector breeding by environmental management techniques. **Personal protective measures** to prevent mosquito bites are the most practical means of avoiding infection with WNV. Consult TIM 13, Ultra Low Volume Dispersal of Insecticides by Ground Equipment; TIM 24, Contingency Pest Management Pocket Guide; and TIM 40, Methods for Trapping and Sampling Small Mammals for Virologic Testing. Also see vector surveillance and suppression for malaria.

N. Sindbis Virus.

Sindbis virus belongs to the genus *Alphavirus*, family Togaviridae. It is closely related to the Western equine encephalitis complex. The incubation period is less than a week and symptoms may include fever, headache, rash, and joint pain. Syndromes resulting from Sindbis virus infection have been called Ockelbo disease in Sweden, Pogsta disease in Finland, and Karelian fever in the former Soviet Union. No fatal cases have been reported.

Military Impact and Historical Perspective. Sindbis virus was first isolated in 1952 from *Culex* mosquitoes collected in the village of Sindbis north of Cairo. A role in human disease was recognized in 1961 when Sindbis virus was isolated from patients with fever in Uganda. Although outbreaks of Sindbis virus have caused significant human morbidity in areas of northern Europe and South Africa, this disease is expected to have a minor impact on military operations in North Africa.

Disease Distribution. Sindbis virus is one of the most widely distributed of all known arboviruses. Studies have demonstrated Sindbis virus transmission in most areas of the Eastern Hemisphere. Serological surveys and viral isolations indicate that Sindbis virus is circulating in Egypt and is probably enzootic in other areas of North Africa.

Transmission Cycle(s). A wide range of wild and domestic vertebrates species are susceptible to infection with Sindbis virus. Most experimentally infected wild bird species easily produce viremias high enough to infect several different species of mosquitoes. Wild and domestic birds are considered the main enzootic reservoir. Although several species of domestic mammals can become infected with Sindbis virus, there is no evidence that these infections result in significant illness. Evidence implicates

bird-feeding mosquitoes of the genus *Culex* as the vectors of Sindbis virus in enzootic and human infections. However, viral isolations and transmission experiments have shown that *Aedes* spp., which are less host specific and feed readily on both birds and humans, may be important as vectors linking the enzootic cycle and human infection. Mechanisms that allow the virus to overwinter and survive between periods of enzootic transmission have not been identified.

Vector Ecology Profiles. Egyptian studies implicate four mosquito species as vectors of Sindbis virus in North Africa. *Culex univittatus* and *Cx. antennatus* are the two principal vectors, while *Anopheles pharoensis* and *Cx. p. pipiens* are considered secondary vectors. *Culex p. pipiens* is the most common species throughout the region, and it is also the most anthropophilic of the reported mosquito vectors. *Culex univitattus* is a good vector, but it is less abundant, more exophilic, and more zoophilic than *Cx. p. pipiens*. Consequently, *Cx. univitattus* is considered important in the zoonotic cycle of the disease. *Anopheles pharoensis* is common only in the Nile Valley and feeds readily on man when large domestic animals are not present. *Culex antennatus* is a good vector but is less abundant, more exophilic and more zoophilic than *Cx. pipiens*. In North Africa, current records indicate that *Cx. antennatus* is limited to Egypt.

Culex univittatus occurs year-round in southern Egypt but has a pronounced seasonal distribution from May to October in the Nile Delta. *Culex antennatus* is more seasonally distributed; it occurs primarily from June through September and is uncommon from December through April. *Culex p. pipiens* breeds year-round in southern Egypt along the Nile River and its tributaries and from May to October in the Nile Delta. It can be found year-round indoors, since it overwinters in houses. In the rest of North Africa, it exhibits more of a seasonal distribution (from April to October), particularly in the northern tier of this region. It is common in urban areas, where human sewage runoff provides larval habitats. *Anopheles pharoensis* is seasonally abundant from May to October. Further details on the vector ecology of *Cx. univittatus*, *Cx. antennatus*, and *Cx. p. pipiens* are discussed further under Rift Valley fever, while *An. pharoensis* is discussed in detail in the malaria section. The geographic distribution of these and other mosquitoes in North Africa is summarized in Appendix A.1.

Vector Surveillance and Suppression. Consult this section for West Nile fever and malaria.

O. Other Arthropod-borne Viruses.

Many enzootic arboviruses are circulating in North Africa, but little is known about them. Available epidemiological information indicates that they would have a minor impact on military operations. However, medical personnel should be aware of these arboviruses because they will frequently be treating fevers of unknown origin.

Tahyna virus (Bunyaviridae, *Bunyavirus*, California group) is widely distributed in Europe, Africa, and Asia. Infection with Tahyna virus is associated with fever lasting 3 to 5 days, headache and nausea, but symptoms are usually mild. Complications are rare. No residual sequelae and no deaths have been recorded due to Tahyna viral infection.

Wild mammals, especially hares, rabbits and hedgehogs, are reservoirs. Birds do not appear to be involved in the circulation of the virus. Antibodies to Tahyna virus have been found in cattle. A 1980 study found antibodies against Tahyna virus in 18.4 % of the small mammals collected in different parts of Tunisia.

A *Phlebovirus* named Tunis virus was first isolated in 1989 from the tick *Argas reflexus hermanni* parasitizing a colony of domestic pigeons in Tunis. The pathogenic potential of this virus for man is unclear, but it is unlikely that Tunis virus will be a medical risk since *A. r. hermanni* feeds strictly on birds. However, Quaranfil virus (an *Arenavirus*) has been isolated from the same tick species in Egypt where it has produced a mild febrile illness in children. Antibodies against Quaranfil virus have also been detected in the sera of Egyptian children living near an egret rookery.

Soldado virus (*Nairovirus*), Essaouira (*Orbivirus*) and Kala virus (*Orbivirus*) have been isolated from the tick *Ornithodoros maritimus* parasitizing marine birds in Morocco. Soldado virus produces a self-limited febrile illness with pruritis in humans. Risk of infection with these viruses would be restricted to individuals exposed to colonies of marine birds and therefore, these viruses would have little military significance.

VI. Militarily Important Vector-borne Diseases with Long Incubation Periods (>15 days)

A. Leishmaniasis. This potentially disfiguring and sometimes fatal disease is caused by infection with protozoan parasites of the genus *Leishmania*. Transmission results from bites of infected phlebotomine sand flies. All vectors of leishmaniasis in the Old World are in the sand fly genus *Phlebotomus*. Incubation in humans may take as little as ten days or more than 6 months. Symptoms include ulcerative cutaneous lesions (cutaneous leishmaniasis or CL), lesions in the mucosal areas of the mouth and/or nose (mucocutaneous leishmaniasis or MCL), and internal pathological manifestations resulting in fever, swollen lymph glands, anemia, enlargement of the liver and spleen, and progressive emaciation and weakness (visceral leishmaniasis or VL). In North Africa, both CL and VL are important public health problems.

CL (Baghdad boil, Jericho boil, Oriental sore), caused by infection with *Leishmania major* or *Le. tropica*, typically appears as a nonhealing ulcer. The lesion usually develops within weeks or months after a sand fly bite and slowly evolves from a papule to a nodule to an ulcer. Cutaneous lesions may resolve quickly (2 to 3 months) without treatment or they may become chronic (lasting months to years) and will seldom heal without treatment. *Leishmania major* produces a wet lesion that usually heals spontaneously while *Le. tropica* causes a more severe dry ulcer. Scarring is associated with healing. In endemic areas, such scars are common among both rural and urban populations. Life-long immunity to the infecting *Leishmania* species normally results.

VL (Kala-azar, Dum Dum fever) is the most severe form of leishmaniasis with as high as 95% mortality in untreated cases. It is a chronic disease and, without treatment, is marked by fever (2 daily peaks), weakness and, as the parasites invade internal organs,

weight loss coupled with enlargement of spleen and liver that may resemble severe malnutrition. It should be noted that cutaneous lesions may also be seen in human visceral leishmaniasis cases, but the chronic visceralizing nature of the disease is the main concern. In the Old World, VL is usually attributed to *Le. donovani* or *Le. infantum.* Viscerotropic *Le. tropica* has been reported and was described in veterans of the Persian Gulf war. The incubation period for VL is usually 4 to 6 months but may be as short as 10 days or as long as 2 years. By the time the disease is diagnosed, patients have usually forgotten any contact with sand flies. In endemic regions it is a disease of the young and old who succumb to it disproportionately. Epidemics of VL often follow conditions of severe drought, famine or disruption of native populations by wars that produce large numbers of refugees. In Sudan, between the years 1991 and 1996, there were reports of 10,000 treated cases and 100,000 deaths from VL.

Military Impact and Historical Perspective. Leishmaniasis is a persistent health threat to U.S. military personnel because troops deploy or conduct military exercises in locations where the disease is endemic. The potential for this disease to compromise mission objectives is significant. Soldiers exposed to sand fly bites while deployed to the region are highly susceptible to infection with *Leishmania.* Immunity among US military personnel is essentially nonexistent, and recovery from CL does not confer immunity to VL. In the Karum River Valley of Iraq, US forces suffered 630 cases of the disease in a 3 month period during WWII. During the 1967 "Six Day War," Israeli soldiers camped near Jericho in the Jordan Valley suffered a 50% attack rate of *Le. major*. In the northern Sinai desert, 113 cases of *Le. major* were reported from Multinational Forces and observers from 1973 through 1991. In 1990 to 91, twenty cases of CL due mainly to *Le. major* and 12 cases of VL due to *Le. tropica* were diagnosed when 697,000 allied soldiers were deployed to the Arabian Peninsula during Operations Desert Shield and Storm. Although this was a small number of cases, the potential for leishmaniasis to cause intransigent post-deployment diagnostic problems and threaten blood supplies had not been anticipated. VL is easily transmitted by blood transfusion, and prolonged incubation periods of this disease can result in the donation of infective blood. Returnees from the Persian Gulf War were barred from donating blood for up to 2 years, severely impacting blood supplies.

Diagnosis of leishmaniasis is difficult at best, and providing proper care for service members who may have been exposed or infected is a long, costly and complex process. Treatment of VL usually requires 20 or more days and consists of injections with pentavalent antimony (Pentostam). Because this drug is not registered for use in the US, it must be administered under an experimental protocol at an approved medical treatment facility. Estimated leishmaniasis-related costs can exceed US $17,000 per patient, with an average of 92 lost duty days per patient. Other important but less quantifiable costs include loss to the unit, personal distress, and delay of career progression.

Disease Distribution. CL due to *Le. major* ("wet sore") occurs in the Old World throughout the Mediterranean basin countries of North Africa, the Middle East and southern Europe, parts of sub-Saharan Africa, southern Asia, the western part of the Indian subcontinent, and China. In North Africa it is distributed in a belt from Marrakech and Casablanca through Algiers, Tripoli to Cairo and Alexandria to the Sinai.

FIG. 11. DISTRIBUTION OF CUTANEOUS LEISHMANIASIS IN NORTH AFRICA (DARK SHADING)

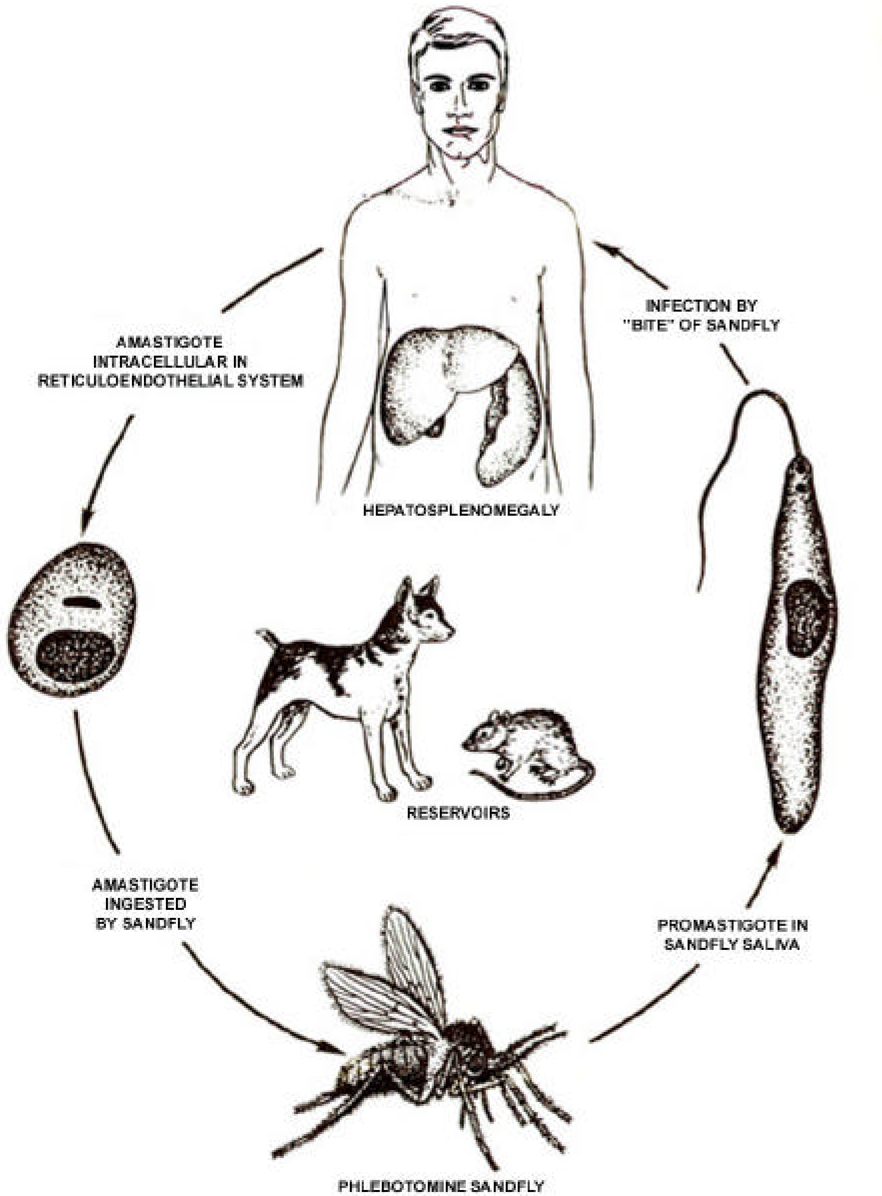
It is endemic from the coastal Mediterranean through the pre-Saharan steppe and into arid desert areas (Figure 11). In Libya outbreaks of CL have been associated with newly inhabited agricultural projects in rural areas. Localities of *Le. major* share a semi-arid to arid climate with a hot dry season lasting 6 or more months, in which air temperatures regularly exceed 35ºC and frequently exceed 40ºC. All these localities are in areas of low relief, mostly almost flat, and share soils sufficiently deep and cohesive for the construction of deep, durable, rodent burrows. The disease is generally endemic throughout rural areas of these countries where colonial rodent reservoirs (jirds or gerbils), such as *Rhombomys*, *Psammomys* or *Meriones*, and the proven vector, *Phlebotomus papatasi,* are present. The burrow systems of these animals provide protection against extremes of external temperature and desiccation, and contain considerable amounts of organic debris. CL caused by *Le. tropica* ("dry sore") is distributed in a similar belt across North Africa from the Canary Islands to Egypt. It is widespread in the urban areas of these countries although *Le. tropica* is becoming more common in rural highland villages.

VL due to *Le. infantum* occurs in the Mediterranean basin countries of North Africa, the Middle East and southern Europe, in East Africa, South Central Asia, and in China. In North Africa it is less prevalent than CL. It is reported sporadically throughout the region, but is not highly endemic in any North African country. It is endemic in the northern Mediterranean coastal regions that have a humid and subhumid climate and generally does not extend into the less humid steppe region (Figure 12). VL is primarily a disease of rural populations, but in some areas periurban transmission occurs sporadically. In Algeria the incidence of hospital diagnosed VL has increased dramatically in recent years. About 500 cases were recorded between 1965 and 1974. From 1985 to 1990 there were 1,122 cases, the majority of which were in the region of Tisi-Ouzzou in the Greater Kabylia. This increase was attributed to the cessation of insecticide spraying as part of the malaria control program. A small number of cases have been identified in Algiers. VL wasn't confirmed in Egypt until 1983. Nearly all known cases have occurred in the Alexandria area. There are few published reports on the status of leishmaniasis in Libya. Only about 50 cases of VL have been confirmed this century. Mehabresh and El-Mauhoub reported 21 cases hospitalized in Benghazi between 1982 and 1990. In Morocco 134 cases were reported between 1957 and 1974, but a significant increase in the number of cases has been noted since then. There have been 50 to 100 cases of VL reported annually in Tunisia since 1980. VL is endemic north of the Tunisienne Mountains, and in recent years endemic areas have been extended from the sub-humid north to the semi-arid south due to the development of water resources and extensive irrigation. VL has not been reported from the Canary Islands. The existing prevalence data are considered to be a gross underestimate of the true epidemiological status of leishmaniasis in North Africa.

Transmission Cycles. *Le. major* is a parasite of colonial desert rodents, especially gerbils such as the fat sand rat, *Psammomys obesus.* Female *Phlebotomus papatasi* inhabit the burrow systems of these rodents and acquire infections while feeding on their rodent hosts. Amastigotes (the mammalian form of the *Leishmania* parasite) ingested with the bloodmeal transform to a flagellated promastigote form within the gut of the

FIG. 12. DISTRIBUTION OF VISCERAL LEISHMANIASIS IN NORTH AFRICA (DARK SHADING)

Figure 13. Life Cycle of *Leishmania*



female fly. In addition to a bloodmeal, the female fly seeks and consumes sugar from the plants in the area during subsequent nocturnal flights. These sugars help maintain *Leishmania* infections in the flies. Promastigotes multiply in the gut of the sand fly within the bloodmeal and undergo development to an infective form called the metacyclic promastigote. By the time the bloodmeal is digested and the fly is ready to lay its eggs, infective metacyclic promastigotes are ready to be transmitted to the next vertebrate host when the sand fly feeds again (Figure 13). In *Le. major* foci, where the principal reservoirs are colonial rodents, humans are considered accidental or incidental hosts, becoming infected when their habitat overlaps that of the rodent host. In urban *Le. tropica*, humans may serve as reservoirs. In rural areas, non-human hosts of *Le. tropica* may include wild and domestic rodents living in close proximity to humans. Female sand flies are quiet "stealth biters" and may go unnoticed by military personnel as they fly and bite from dusk to dawn. They may also bite during the daytime if disturbed in their hidden resting sites. Infective-stage promastigotes (metacyclics) are deposited in the skin of a susceptible host when the infected sand fly takes subsequent bloodmeals. There they are engulfed by white blood cells or macrophages, in which they transform to amastigotes. These proliferate in the host's cell until it ruptures, at which time they reinvade other host cells. At the skin surface, the tiny bite site becomes a small red papule that enlarges and ulcerates, with a raised edge of red inflamed skin. This inflamed area is where macrophages continue to engulf parasites and assist in their multiplication. The ulcerated sores may become painful, last for months and, in uncomplicated CL caused by *Le. major*; eventually heal to form the characteristic scars commonly seen in some endemic areas of the region.

CL caused by *Le. tropica* ("dry sore") is most common in densely populated urban centers of North Africa and is considered to have a human-sand fly-human (anthroponotic) transmission cycle, with no recognized sylvatic reservoir. In rural highland villages the disease is thought to have a zoonotic transmission cycle, although a sylvatic reservoir(s) has not been confirmed. Commensal rodents and dogs have been suggested as reservoir hosts.

The cycle of development of parasites causing VL is essentially the same as described for CL. The differences when dealing with VL caused by *Le. infantum* and *Le. donovani* are the species of sand fly vectoring the disease and the reservoirs for that disease. In North Africa, VL is caused by infection with *Leishmania infantum* and is a zoonotic disease of wild canids. *Leishmania infantum* has been found in jackals and foxes in rural areas, as well as in feral and domestic dogs. Incidental infections in humans are common where dogs live in close association with their owners and where the habitats of wild and domestic reservoirs overlap. In addition to wild and domestic canids, and man, *L. infantum* has been isolated from infected rats (*Rattus rattus*) in southern Saudi Arabia next to Yemen, expanding the list of potential reservoirs. VL due to *Le. donovani* is reported from some countries in the region, but such cases are less frequent than those due to *L. infantum* and usually are imported. As mentioned earlier, a less virulent, viscerotropic form of *Le. tropica* has also been reported from the Middle East.

Vector Ecology Profiles. The proven sand fly vector of *Le. major* in the region is *P. papatasi*, and suspected vectors include *P. alexandri* and *P. bergeroti.* The incriminated vectors of *Le. tropica* in the region include *P. sergenti*, *P. chabaudi*, and *P. saevus*. Proven or suspected vectors of Le. infantum in North Africa are P. ariasi, P. longicuspis, P. perniciosus, P. perfiliewi and P. langeroni.

Adult sand flies rest during the daytime in dark, humid, protected areas, such as rodent burrows, rock crevices and caves. The preparation of military bunkered ground positions in desert areas provides additional protected daytime resting sites for phlebotomine sand flies. In urban areas, sand fly adults often rest in dark, cool, humid corners of inhabited human and animal structures. Abandoned structures and their vegetative overgrowth often become attractive wild rodent habitats and foci of rural CL.

Vegetation is important as a sugar source for both male and female sand flies. Sugar is required for females as an energy source and is important to the survival of parasite infections. Eggs are developed after a bloodmeal and are deposited in dark, humid, protected areas. They develop into minute caterpillar-like larvae that feed on mold spores and organic debris. The larvae go through four instars and then pupate near larval feeding sites. Development from egg to adult requires 30 to 45 days, depending on feeding conditions and environmental temperatures. Phlebotomine sand fly eggs, larvae and pupae have seldom been found in nature, although exhaustive studies and searches have been made. The adult female has been observed to spread eggs around rather than ovipositing in single egg laying sites. The larvae are believed to be widely distributed in endemic environments but are probably below the ground surface in termite mounds, rodent burrows or other tunnels where temperature, humidity and mold growth provide ideal growing conditions. The dusk-to-dawn movement of adults is characterized by flight just above the ground surface to avoid wind. Adult sand flies generally do not travel great distances, and most flights are believed to be less than 100 meters. The females fly in a low hopping flight just above the ground in search of rodent hosts. Both male and female sand flies seek plant sugars from local vegetation. Sand fly habitats in the region range in altitude from desert areas below sea level to 2,800 m in the mountains. Where seasonal temperature and rainfall changes occur, large numbers of adult sand flies are common in the warmer months of April through October, especially after rains. However, *Le. tropica* peak seasonal incidence occurs during January and February.

The dusk to dawn flights of sand flies coincide with the nomadic activity of peoples of the region, who often travel at night to avoid the extreme heat of daytime hours. Areas with some vegetation, and cliffs, rock outcroppings, or other geologic formations that allow for suitable hiding places and daytime resting sites are important habitats. Exact information on reservoirs and vectors will require more extensive study in many countries of the region. Vast areas of these countries remain unsurveyed for vectors and disease. When searches are made, sand fly vectors are often found in areas where they were previously unknown.

Vector Surveillance and Suppression. See Sand fly fever.

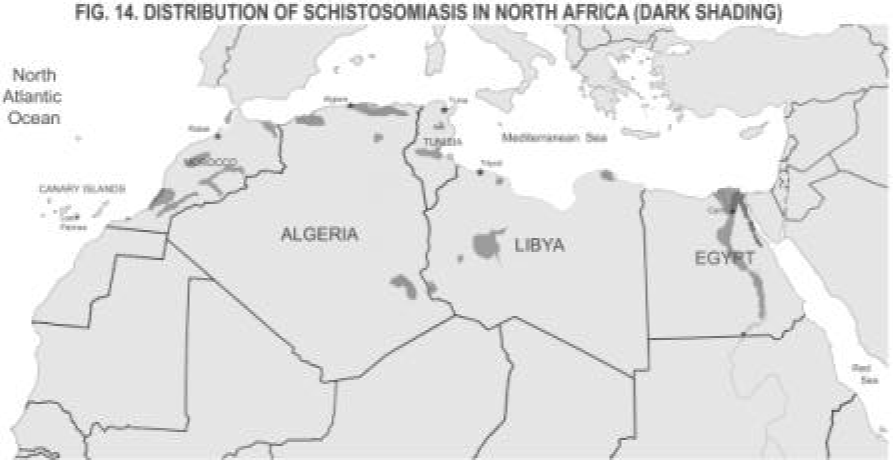
B. Schistosomiasis. (Bilharziasis, Snail fever)
This disease is caused by trematodes in the genus *Schistosoma* that live in the veins of humans and other vertebrates. Eggs from adult worms produce minute granulomata and scars in the organs where they lodge. Symptoms are related to the number and location of the eggs. The WHO considers five species of schistosomes significant in terms of human disease. *Schistosoma mansoni*, *S. japonicum*, *S. mekongi* and *S. intercalatum* give rise to primarily hepatic and intestinal symptoms. Infection with *S. haematobium* usually produces urinary manifestations. The most severe pathological effects are the complications that result from chronic infection. Symptoms of acute disease appear 2 to 8 weeks after initial infection, depending on the parasite species, and can be intense, especially in nonimmune hosts. Clinical manifestations include fever, headache, diarrhea, nausea and vomiting. Blood may be present in the urine but usually occurs later in the disease. The acute stage of schistosomiasis is usually more severe in the Asian forms *S. japonicum* and *S. mekongi* than in *S. mansoni*, *S. intercalatum*, or *S. haematobium*.

Military Impact and Historical Perspective. The first documented cases of schistosomiasis in US military personnel occurred in 1913 among sailors assigned to the Yangtze Patrol in China. Significant portions of the crews on some patrol boats were incapacitated. American forces were not deployed in areas endemic for schistosomiasis during World War I. However, infection was prevalent among Allied Forces engaged in Mesopotamia and various parts of Africa. During World War II, the US Army hospitalized 2,088 patients with schistosomiasis. More importantly, an average of 159 days were lost per admission, almost half a year per case. Over 1,500 cases of acute infection due to *S. japonicum* were reported in US troops during the reinvasion of Leyte in the Philippines. Allied and Axis troops deployed in the North African and Middle East campaigns experienced high rates of infection. During the early 1950s, troops of the People's Republic of China were training along the Yangtze River for an amphibious landing on Taiwan. However, the invasion had to be cancelled when 30,000 to 50,000 cases of acute schistosomiasis (10 to 15% of the invasion force) occurred. By the time the Chinese army recovered, the US had established the Taiwan Defense Command and had begun routine patrols of the Taiwan Strait. Schistosomiasis was rare among US military personnel during the Vietnam War.

Disease Distribution. Over 200 million persons are infected with schistosomiasis worldwide, causing serious acute and chronic morbidity. *Schistosoma mansoni* and *S. haematobium* are endemic in North Africa but are now a major public health problem only in Egypt. Current endemic areas in the region are illustrated in Figure 14.

Algeria: *Schistosoma haematobium* occurs in two principal foci. One is in the north, primarily in the Mitidja Plain area near Algiers (including the communities of El Harrach, Gue de Constantine and Reghaia) and also at Khemis El Kechna, which is associated with the dam of the El Hamiz River. The second area is in the southeast near Tassili N'Ajjer, with recognized foci close to Djanet, Iherir and Tamadjert. Historically foci have occurred in the Tell Mountains near the Mediterranean coast, in the irrigation canals

FIG. 14. DISTRIBUTION OF SCHISTOSOMIASIS IN NORTH AFRICA (DARK SHADING)



of the Jdiouia Valley east of Oran, near Biskra, and near Aguedal -Anefid in the Beni Abbes region south of Bechar. However, the current endemic status in these areas is unknown.

Egypt: Historically (1930s to 1970s), both *S. mansoni* and *S. haematobium* were well established in Egypt. In the Nile Delta north of Cairo, the prevalence of *S. haematobium* was higher than that of *S. mansoni*, and *S. haematobium* was the only species found south of Cairo and along the Nile River Valley in Middle and Upper Egypt. In the past two decades, the prevalence of *S. haematobium* has declined in the Nile Delta, and *S. mansoni* has become the predominant species. In addition, *S. mansoni* has become established at several sites along the Nile River in Middle and Upper Egypt, and *S. haematobium* has become established at new settlements in the Sinai and Middle and decline in prevalence of *S. haematobium* has been associated with reductions in the population of bulinid snails in the Delta. Changes in ecological conditions due to the construction of the Aswan High Dam in the 1960s (e.g., changes in water levels, flow velocity, water chemistry and concentrations of suspended particles), use of chemical fertilizers, and industrial waste from the city of Cairo have favored the survival of *Biomphalaria* but not *Bulinus*. This reversal of the relative abundance of snail species has made *S. mansoni* the predominant species, while *S. haematobium* is only transmitted in focal areas north of Cairo. During the 1980s, a 40% decline in the prevalence of *S. haematobium* in the Delta caused urinary schistosomiasis to disappear in some areas.

Active control programs throughout the country for the past two decades have reduced infection rates in most governorates, but schistosomiasis remains a major public health problem, particularly in areas of increased irrigation and new agricultural cultivation. The Aswan Dam supplies a dense network of canals and drains that support intensive irrigated farming the entire year. In the 1980s, nationwide infection rates of *S. mansoni* and *S. haematobium* averaged 38% and 35%, respectively. Primary health care facilities located throughout the Nile Delta and along the Nile River have provided free diagnosis and treatment with praziquantel for more than a decade. There is increasing evidence that *S. mansoni* may be developing resistance to praziquantel in some parts of Egypt. In one village in Gharbiya Governorate, approximately 50% of the population examined in 1977 was infected by *S. mansoni*. In 1990, only 9% of the population sampled from villages in the same governorate were infected. The Ministry of Health now estimates that nationwide about 10% of the exposed population is infected with schistosomiasis, and most of those cases are due to *S. mansoni.*

Libya: Urinary schistosomiasis caused by *S. haematobium* is focally endemic. Subsequent to control measures implemented during 1969, infection rates dropped below 7%, but the control measures were discontinued during 1986, and infection rates may now be higher.

Currently, transmission occurs year-round, primarily near manmade irrigation and other water distribution systems and near oases. Recognized foci of *S. haematobium* are primarily within a 300 km radius of the city of Sabha. Additional foci occur in the

vicinity of Ghat on the Algerian border and in the city of Darnah. *Schistosoma mansoni* has been reported near the city of Tawurgha. A 1990 study found the infection rate in Tawurgha to be over 20%.

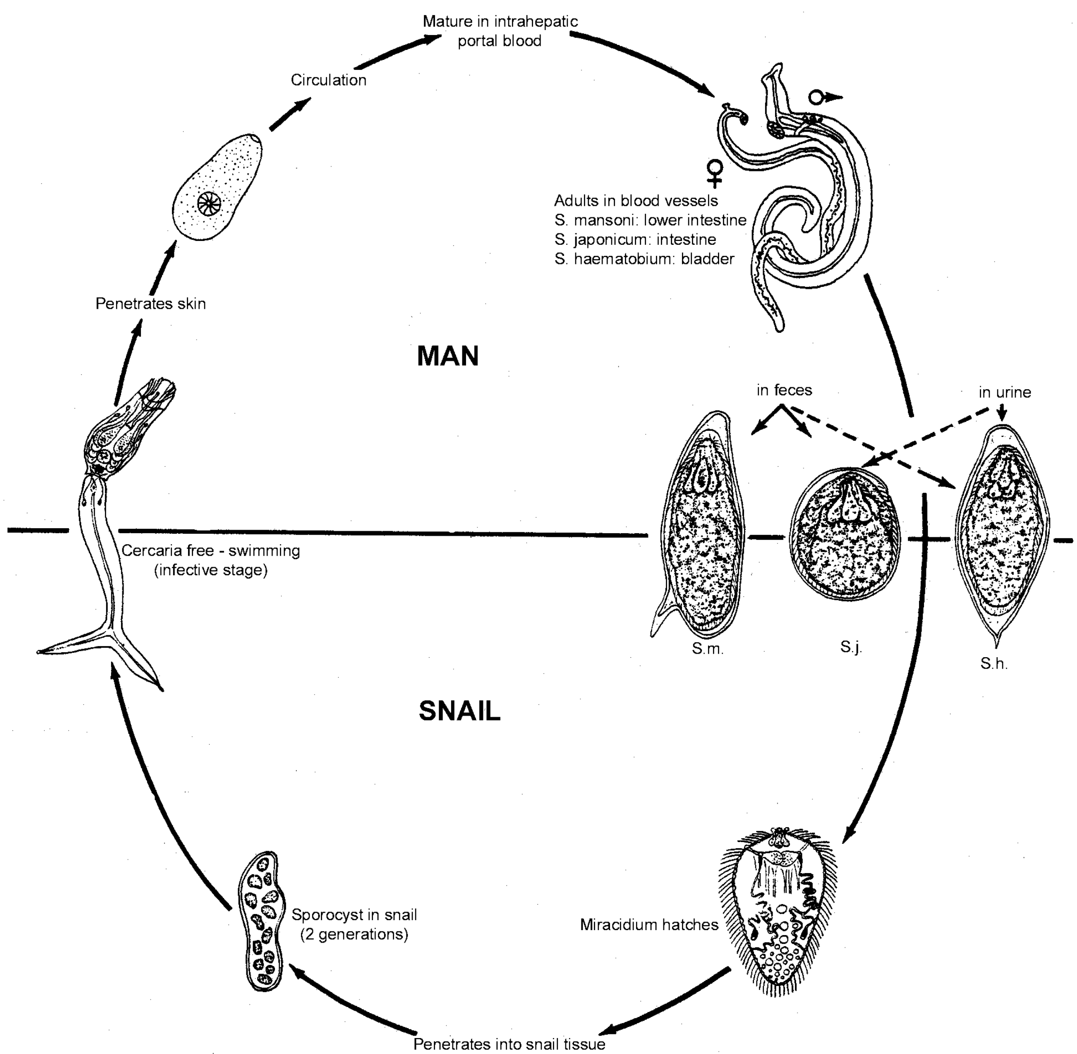
Morocco: In Morocco, the construction of modern surface irrigation schemes over the last few decades has led to expansion of the range of *Bulinus truncatus* and, as a result, of *S. haematobium* from endemic southern oases to many parts of the country. In 1982, a successful national control program was initiated. Currently, urinary schistosomiasis is widespread but prevalence is low. The objectives of the control program have shifted from control to eradication. Foci of *S. haematobium* are found along wadis and slopes of the Anti- and Haut Atlas Mountains, in coastal areas (except for an area on the western coast), and in oases and irrigated agricultural areas. Risk-free areas include the coastal area between Rabat and Essaouira, and the provinces of Fes, Meknes and Taza.

Tunisia: Urinary schistosomiasis caused by *S. haematobium* is endemic at low levels. Infection rates declined to less than 1% in endemic foci following implementation of successful control measures. However, snail intermediate hosts are widespread. Foci of *S. haematobium* occur in oases in Gafsa and Gabes Governorates, with an isolated focus in the village of Hadjeb El Aioun, Kairouan Governorate.

Transmission Cycle(s). The life cycles of the various schistosomes infecting man are similar. A generalized life cycle appears in Figure 15. Humans are infected when they are exposed to cercariae in infested fresh water. A single infected snail intermediate host may release 500 to 2,000 cercariae daily. Cercariae are infective for about 12 hours after being released from the snail. After cercariae penetrate the skin and enter the blood or lymph vessels, they are carried to blood vessels of the lungs before migrating to the liver, where they develop into mature adult male and female worms. They mate in the liver and migrate as pairs to veins of the abdominal cavity, usually the superior mesenteric veins in the case of intestinal forms (*S. mansoni*, *S. mekongi*, *S. intercalatum* and *S. japonicum*) and the venous plexus of the urinary bladder in the case of *S. haematobium*. Four to 6 weeks after initial penetration of the skin, adult females begin laying eggs. Female worms can deposit from 300 to 2,500 eggs per day. Adult worms live 3 to 7 years, but life spans of 30 years have been reported. Only about 50% of the eggs produced reach the bladder or intestine, where they are excreted in the urine and feces. The rest become lodged in the liver and other organs. The immunological reaction to the eggs is the primary cause of both acute and chronic clinical symptoms. The degree of chronic disease is directly related to the number of eggs deposited in the tissues.

After excretion in urine or feces, a schistosome egg hatches in fresh water, releasing a single miracidium that infects an appropriate species of snail. The miracidium can survive as an infective free-living entity for less than a day. Miracidia undergo a complicated cycle of development in the snail, but after 30 to 60 days each gives rise to several hundred infective cercariae. Humans are the principal hosts for both *S. mansoni* and *S. haematobium*, although natural infections of *S. mansoni* have been found in rodents in Egypt.

Figure 15. LIFE CYCLE of *Schistosomes*



Vector Ecology Profiles.
Biomphalaria alexandrina, *Bi. glabrata*, *Bi. pfeifferi*, *Bulinus contortus* and *Bu. truncatus* are the intermediate hosts of schistosomes in North Africa. *Schistosoma mansoni* is associated with *Bi. alexandrina*, *Bi. glabrata* and *Bi. pfeifferi*, while *S. haematobium* is associated with and *Bu. contortus* and *Bu. truncatus*. In a limited experimental study, *Planorbarius metidjensis* was shown to be an effective intermediate host of *S. haematobium.*

Specific distributions of snail hosts:

a. *Biomphalaria alexandrina*. **Egypt:** formerly restricted to the Nile Delta and its canals, this species is now distributed throughout the Nile Delta with foci in the Sinai Peninsula and along the Nile Delta River in Middle and Upper Egypt. In the last 20 years, *Bi. alexandrina* has been replacing *Bu. truncatus* as the predominant snail species, particularly in Middle and Upper Egypt. **Libya:** distributed in springs or muddy edges of swamps in Taourga near the coast between the Tripoliatana and Cyrenaica Regions.

b. *Biomphalaria glabrata.* This introduced species is distributed along irrigation and drainage systems in the Nile Delta areas of Giza, Qalyubiya and Kafr El Shiekh Governorates of **Egypt**. This invading snail is less susceptible to Egyptian strains of *S. mansoni*, but it produces larger numbers of cerca riae than *Bi. alexandrina* and has a higher reproductive capacity.

c. *Bulinus truncatus*. **Algeria:** distribution is mainly along the coast just east of Algiers, and in two isolated foci at Biskra and Jdiouia, where pools of water occur in riverbeds or oases. **Egypt:** *Bulinus truncatus* occurs in limited foci throughout the Nile Delta in Lower Egypt, as well as the Nile River and its tributaries and irrigation canals to the southern border of Upper Egypt with Sudan. **Libya:** distributed in the stream valleys of Ubari and Sebha Districts, which comprise of a chain of oases. **Tunisia:** occurs mainly in the Chott El Ghatsa and Chott El Djerid areas. It is also found in El Hamma District. **Morocco:** widespread in lowland areas along the Atlantic coast southwest of Tangiers and the Mediterranean coast near Nador. In the southwest Atlantic coastal region, this species is widespread from Agadir to Tiznit, and inland from Guelmim to Taroudant (along the Qued Souss). In the Atlas Plateau, near Algeria, it occurs along the Qued Dades, the Qued Ziz, and near Tagounit. In the Atlas Mountains, it occurs in the area of Marrakech and Beni -Mellal.

d. *Bulinus contortus*. This species occurs in limited areas in **Algeria** (El Harrach near Algiers) and in Ubari District of **Libya**.

e. *Planorbarius metidjensis*. This species occurs in **Morocco's** Agadir Province.

f. *Biomphalaria pfeifferi*. This species has a limited distribution in **Algeria**, near Algiers.

General Bionomics

Vector snails are focally distributed in rural and urban areas, as sociated with slow-moving streams, irrigation canals, oases, cisterns, and aqueducts. Expansion of the number of irrigation projects throughout the region has increased the habitats for snails. Highland areas above 500 m or streams in steep terrain are unlikely snail habitats. Concrete-lined, covered canals are usually poor habitats, while soil-lined canals that allow reeds or other marshy vegetation to grow provide excellent snail habitats. As salinity in irrigated areas decreases because of constant leaching, many previously saline agricultural areas become suitable snail habitats. Uncovered concrete canals or tanks may be suitable for snails and must be treated with molluscicides. Wadis (also called queds or chotts), oases, and domestic water storage tanks also may provide suitable snail habitats. Tidal areas are not suitable habitats for snail hosts. Snails survive dry seasons by burrowing beneath riverbeds or under moist stones. Snails may be transported by man and sometimes by birds. Self-fertilization is common among these hermaphroditic snail species, a characteristic that enhances the dispersal of snails, since only a single founder would be necessary to establish a colony.

Specific Bionomics

Bulinus truncatus prefers primary irrigation canals containing abundant vegetation, where it can be found in siphon boxes, pumping equipment and weirs. It can also be found under small stones in springs or in the muddy edges of swamps. It is intolerant of a pH below 5.0. In most of North Africa, there are two generations per year. Snails are active year-round in most of the region. *Biomphalaria alexandrina* prefers swamps or thick mats of aquatic vegetation covering springs. The often-saline edges of swamps are unfavorable habitat. This species is more tolerant than *Bu. truncatus* of slow-flowing water with low oxygen content. *Biomphalaria glabrata* occurs in areas similar to those utilized by *Bi. alexandrina*, and also inhabits shallow, stagnant watercourses or swamps. Its distribution and abundance is increasing in the Nile Delta. This species tolerates a higher temperature, has a greater reproductive capacity, and lives longer than *Bi. alexandrina*. *Planorbarius metidjensis* tolerates more polluted, temporary collections of water than *Bu. truncatus* and has three generations per year instead of two. The bionomics of *Bi. pfeifferi* and *Bu. contortus* have been little studied, but they generally occur in habitats similar to those of *Bu. truncatus*.

Vector Surveillance and Suppression. The most important preventive measure in reducing the incidence of schistosomiasis is avoidance of fresh water with infective cercariae. Assume that all fresh water in endemic areas is infested unless proven otherwise. The absence of snails in an area does not preclude infection, since cercariae can be transported considerable distances by water currents. Combat commanders and troops must be instructed in the risk of infection and measures for schistosomiasis prevention. No topical repellent is currently available that provides long-term protection against cercarial penetration. Experimental studies have shown the insect repellent DEET to provide a significant level of protection. Cercariae penetrate the skin rapidly, so efforts to remove cercariae after exposure by applying alcohol or other disinfectants to the skin have limited value. Standard issue BDUs offer substantial protection against

penetration, especially when trousers are tucked into boots. Rubber boots and gloves can provide additional protection for personnel whose duties require prolonged contact with water containing cercariae.

Cercarial emergence from snails is periodic, and the numbers found in natural waters vary with the time of day. Light stimulates cercarial release for *S. mansoni* and *S. haematobium*, and in North Africa peak numbers of cercariae are found from about mid-day to 1400 hours. Minimal numbers of cercariae are present early in the morning and at night. Restricting water contact during peak cercarial density may reduce risk of infection. However, stepping on and crushing an infected snail will release thousands of cercariae.

Cercariae are killed by exposure for 30 minutes to concentrations of chlorine of 1 ppm. Treating water with iodine tablets is also effective. Heating water to 50^{o} C for 5 minutes or allowing it to stand for 72 hours will render it free of infective cercariae. Water purification filters and reverse osmosis are effective in removing cercariae.

Molluscicides may be applied area-wide or focally by preventive medicine teams to eliminate snails from aquatic areas likely to be used by military personnel. Consult TIM 23, A Concise Guide for the Detection, Prevention and Control of Schistosomiasis in the Uniformed Services, and TIM 24, Contingency Pest Management Pocket Guide, for molluscicide recommendations and application techniques. There is little evidence that snail intermediate hosts have developed resistance to commonly used molluscicides like niclosamide.

The provision of piped water to houses or installation of water taps for public use will help reduce human contact with infested water and interrupt transmission of infection in native populations.

C. Bancroftian Filariasis.
Bancroftian filariasis is caused by the nematode *Wuchereria bancrofti*, which normally resides in the lymphatic systems of infected humans. Eight to 12 months after infection, adult female worms release thousands of microfilariae (prelarval filarial worms) into the circulatory system. Acute reaction to infection includes swelling of lymph nodes, fever and headache, and allergic reaction to metabolic products of filariae. However, many individuals are asymptomatic in the early stages of infection. Female nematodes continue to produce microfilariae over the next 15 to 18 years. Chronic filariasis develops slowly, with recurrent episodes of fever and inflammation of the lymph glands. Microfilariae can obstruct the lymphatic system, causing the legs, breasts or scrotum to swell to grotesque proportions, a chronic condition known as elephantiasis. This occurs only after repeated infections. Death of numerous microfilariae resulting from drug therapy may cause severe immune reactions.

Military Impact and Historical Perspective. Microfilariae of *W. bancrofti* were first discovered in the blood of a patient in Brazil in 1866. This was the first discovery of a pathogen that was transmitted by insects. Over 70 million people worldwide are

estimated to be infected with *W. bancrofti*, resulting in serious economic costs to developing countries. The long incubation period and requirement for repeated infections before chronic clinical symptoms appear render Bancroftian filariasis of little medical significance to military operations. However, military personnel moving into an endemic area from one that is free from filariasis may develop acute symptoms such as swelling of the lymph glands, headache and fever months before larvae become mature. American military forces in the Samoan-Ellice-Wallis Islands from 1942 to 1944 rapidly deve loped swollen lymph glands and swollen extremities following repeated exposure to infected mosquitoes. Acute filariasis is the primary military concern, because its symptoms develop fairly rapidly and may be severe enough to cause removal of troops from their duties. In addition, the sight of people with grotesque deformities caused by chronic infection can have an adverse psychological impact. Medical personnel should be aware that troops with brief exposure to infection are often not diagnosed until a fter they return from deployments.

Disease Distribution. *Wuchereria bancrofti* occurs in most tropical and some subtropical regions including Latin America, Africa, Asia and the Pacific islands. Mass migrations of infected humans are usually required to introduce the disease to new areas. In North Africa, Bancroftian filariasis is endemic only in Egypt, primarily in the eastern Nile River Delta, including Ad Daqahliyah, Al Qalyubiyah, Ash Sharqiyah, and El Giza Governorates (Figure 16). Increases in irrigation along with poor sanitation and improper disposal of wastewater have led to increased populations of *Cx. pipiens* and transmission of filariasis. A survey of 325,000 residents in 314 villages in 6 governorates of the Nile Delta revealed that the prevalence of lymphatic filariasis increased from <1% in 1965 to > 20% in 1991. The prevalence of filarial antibodies in students tested from 5 villages in Al Qalyubiyah Governorate was 17.2% during 1993. In the principal foci of t he Nile Delta, transmission occurs year-round but is elevated from May to October.

Transmission Cycle(s). Microfilariae circulating in human blood are ingested by mosquitoes and undergo several days of development before the vector can transmit infective stages of the nematode. Infective parasites enter the bloodstream directly during a mosquito bite. A few nematode larvae are deposited on the skin and can enter the host through skin abrasions. In humans, larvae undergo development to adults that produces microfilariae for many years. Over most of its geographic range, including North Africa, *W. bancrofti* microfilariae usually exhibit pronounced nocturnal periodicity and consequently are ingested by night-biting mosquitoes. Peak abundance of microfilariae in the blood occurs between 2300 and 0300 hours. *Culex pipiens quinquefasciatus* is the most common urban vector. In rural areas, transmission is mainly by *Anopheles* spp. and *Culex* spp. There are no known animal reservoirs of Bancroftian filariasis.

Vector Ecology Profiles.
Members of the *Cx. pipiens* complex are the primary if not the exclusive vectors in current endemic areas. This complex includes *Cx. p. pipiens*, *Cx. p. molestus*, *Cx. p. fatigans*, and *Cx. p. quinquefasciatus*. *Anopheles pharoensis*, *Cx. antennatus* and *Cx. univittatus* are considered possible secondary vectors.

FIG. 16. FOCUS OF FILARIASIS IN NORTH AFRICA (DARK SHADING)

The *Cx. pipiens* complex is abundant and widely distributed throughout North Africa and is the most abundant mosquito species complex in Egypt. Females of the *Cx. pipiens* complex deposit egg rafts containing 75 to 200 egg each on the water surface. These rafts are deposited every 3 to 4 days following a bloodmeal. However, *Cx. p. molestus* is autogenous and does not require a bloodmeal prior to oviposition. Adults have an average life span of 2 to 3 weeks. Preferred oviposition sites include cisterns, water troughs, wastewater lagoons, canals and swamps. Larvae of the *Cx. pipiens* complex generally inhabit ground pools with high organic content or swamps with emergent vegetation. Polluted waters, including septic systems, are ideal larval habitats. Larval development in such waters proceeds rapidly, requiring 7 to 9 days within a temperature range of 25 to 30°C. Adults emerge from the pupae in about 2 d ays. Poor sanitation and improper disposal of wastes provide extensive breeding sites for the *Culex pipiens* complex in the densely populated Nile Delta. In a survey of two endemic areas of the Giza Governorate, *Cx. pipiens* comprised 99.6% of the mosquito larvae collected and was the only species of adult mosquito detected in both areas.

Members of the *Cx. pipiens* complex usually prefer to feed on birds but readily feed on humans and large animals like cattle, camels, and goats. Populations of *Cx. pipiens* in Egypt are known to be highly anthropophilic. These mosquitoes are strong fliers, often traveling 5 km or more, if necessary, to find their hosts. Winds over 5 km per hour greatly reduce feeding activity. They frequently enter houses and may awaken their human hosts by producing a high-pitched buzzing sound. Before and after feeding indoors, they rest behind or under furniture and draperies, or in closets. Adults also feed on plant juices and nectar, which provide energy for flight.

Anopheles pharoensis larvae develop in swamps, reedy marshes, and rice fields with emergent vegetation. This species feeds on man and animals from dusk until dawn. It both feeds and rests indoors and outdoors. This is a very large mosquito and a strong flier that can travel 10 km or more to find hosts. This species is common in the Nile Delta and Nile Valley of Egypt, but it is not reported from other North African countries.

Culex univittatus breeds in swamps, slow-moving streams, or ground pools with either high organic content or dense vegetation. The life cycle is similar to that of the *Cx. pipiens* complex. Although *Cx. univittatus* tolerates organic matter, it prefers relatively clean water compared to the *Cx. pipiens* complex and is much more dependent on rai nfall in order to propagate in large numbers. *Culex univittatus* also prefers birds but bites man readily during its peak population periods. This species usually feeds and rests outdoors .

C*ulex antennatus* breeds in sunlit, grassy ponds with relativel y clear, clean water. Rice fields and isolated stream pools are common habitats. Like *Cx. univittatus*, *Cx. antennatus* also feed and rests primarily outdoors. All these *Culex* species begin biting at dusk and continue feeding throughout the night. Additi onal bionomic information on the *Culex* vectors of filariasis can be found in the section on Rift Valley Fever.

Vector Surveillance and Suppression. Light traps are used to collect night-biting mosquitoes, but not all *Anopheles* spp. are attracted to light. The addition of the attractant carbon dioxide to light traps increases the number of species collected. Traps using animals, or even humans, as bait are useful for determining feeding preferences of mosquitoes collected (use of humans as bait must be conducted under approved human-use protocols). Adults are often collected from indoor and outdoor resting sites using a mechanical aspirator and flashlight. Systematic larval sampling with a long-handled white dipper provides information on species composition and population dynamics, which is used when planning control measures.

Mosquitoes can be individually dissected and examined for filarial infection. Large numbers of mosquitoes can be processed more quickly by crushing them in a saline solution and removing filarial worms with a very fine sieve. The parasites can then be concentrated by centrifugation. Careful identification is required so as not to confuse medically important species of filarial worms with species that infect only nonhuman mammals and birds.

Application of residual insecticides to the interior walls of buildings and sleeping quarters is an effective method of interrupting filarial transmission when local vectors feed and rest indoors. Nightly dispersal of ultra low volume (ULV) aerosols can reduce exophilic mosquito populations. Larvicides and biological control with larvivorous fish can reduce larval populations before adults have an opportunity to emerge and disperse. Insecticides labeled for mosquito control are listed in TIM 24, Contingency Pest Management Pocket Guide. Chemical control may be difficult to achieve in some areas. After decades of insecticide use, many *Cx. pipiens* populations are now resistant to insecticides (Appendix C. Insecticide Resistant Arthropods from North Africa). Sanitary improvements, such as filling and draining areas of impounded water to eliminate breeding habitats, should be used to the extent possible.

The proper use of repellents and other **personal protective measures** is thoroughly discussed in TIM 36, Personal Protective Techniques Against Insects and Other Arthropods of Military Significance. The use of bednets impregnated with a synthetic pyrethroid, preferably permethrin, is an extremely effective method of protecting sleeping individuals from mosquito bites. The interior walls of tents can also be treated with permethrin. Buildings and sleeping quarters should be screened to prevent entry of mosquitoes and other blood-sucking insects.

D. Lyme Disease.
Lyme disease is also called Lyme borreliosis, tick-borne meningopolyneuritis, erythema chronicum migrans, Lyme arthritis, and Barnwart's syndrome. The causative agent is the spirochete bacterium *Borrelia burgdorferi*. Like syphilis, the clinical disease manifests itself in acute and chronic stages. Initially there is a highly characteristic expanding skin lesion (erythema migrans) that develops in about 60% of cases. Flu-like symptoms usually occur about the same time. Weeks to months after initial infection, cardiac,

neurological or arthritic symptoms and other joint abnormalities may occur and persist for years. Treatment in the late stages of the disease can be difficult. Chronic Lyme disease can be very debilitating. Early recognition and trea tment are critical.

Military Impact and Historical Perspective. Lyme disease is an emerging infection of public health importance in many parts of the world. Since its recognition in Connecticut during the 1970s, Lyme disease has been reported from 48 states. Since 1995, about 100 cases of Lyme disease have been reported in US Army personnel worldwide. The prevalence of Lyme borreliosis in North Africa is unclear, but it may be an emerging zoonotic disease.

Disease Distribution. Lyme disease is the most common tick-borne infection of humans in the temperate Northern Hemisphere, including North America, Europe and northern Asia. Lyme-like syndromes have been reported from South America, Africa, tropical Asia and Australia, but their epidemiology has not been clarified. Clinical and serological evidence of Lyme disease in humans has been reported from the Canary Islands, Egypt and Tunisia. An immunoassay detected *B. burgdorferi* in 30.5 % of the adult *Ixodes ricinus* collected in Adman, situated in the Kroumiry mountains in northwestern Tunisia. Further studies will be needed to identify vectors, animal hosts and the epidemiology of Lyme disease in North Africa. The future public health significance of Lyme disease in North Africa is uncertain, but it is unlikely to be as important as in temperate areas.

Transmission Cycle(s). All known primary vectors of Lyme disease are hard ticks of the genus *Ixodes*, subgenus *Ixodes*. Infective spirochetes are transmitted by tick bite. Nymphal ticks usually transmit the disease to humans. In most cases, transmission of the pathogen probably does not occur until the tick has been attached for at least 24 hours, so early tick detection and removal can prevent infection. *Borrelia burgdorferi* has been detected in mosquitoes, deer flies and horse flies in the northeastern United States and Europe, but the role of these insects in Lyme disease transmission appears to be minimal. Rodents, insectivores and other small mammals maintain spirochetes in their tissues and blood and infect larval ticks that feed on them. Spirochetes are seldom passed transovarially by female ticks. Small mammals vary in their relative importance as reservoir hosts in different geographic regions. Field mice in the genera *Apodemus* and *Clethrionomys* are the chief reservoirs across Eurasia.

Vector Ecology Profiles.
Ixodes ricinus is the principal vector of Lyme disease in Europe and around the Mediterranean Sea, although other *Ixodes* spp. are possible vectors. *Ixodes ricinus* is focally distributed in the Canary Islands, northern Algeria , Tunisia and Egypt. *Rhipicephalus sanguineus* is a suspected vector based on a study in Egypt. *Rhipicephalus sanguineus* was the only tick collected from domestic animals in the houses of four serologically positive cases treated at the El Shatby University Children's Hospital in Egypt. The authors of a 1991 serological study in the Canary Islands suggested that *Rhipicephalus turanicus* may be the vector and goats may act as a reservoir. *Ixodes ricinus* prefers small rodents, hares, or birds, particularly in its larval and nymphal stages.

Yellow-necked mice, wood mice, and voles (*Clethrionomys* spp.) are favored hosts of larvae, while red fox, hedgehogs, and dogs may be hosts of nymphs. Feeding preferences of nymphal stages are less well known. Adults generally parasitize large mammals, such as deer, sheep, cattle, foxes, or man. Attachment to large mammals is often in the groin area, but may also occur on the back of the neck and in or between the ears. Ticks quest on vegetation, passively awaiting potential hosts. Hard ticks remain attached to hosts for long periods of time, from 2 to 4 days for larvae and 6 to 11 days for nymphs and adults. This facilitates pathogen acquisition and transmission, as we ll as vector dispersal by migrating hosts.

Ixodes ricinus is a three-host tick. There is one larval instar and one nymphal instar, and each stage requires a bloodmeal in order for development to proceed. Mating occurs before feeding, or while the female is feeding on the host. Female ticks deposit up to 2,300 eggs after a bloodmeal and die after oviposition. This species primarily inhabits moist, dense, forest biotopes, where mice and voles are common. *Ixodes ricinus* does not tolerate desiccation well and may die in a matter of weeks if relative humidity falls below 50%. However, in high humidity, adults can survive unfed for over two years. Large herbivores, such as deer and sheep, are required hosts for adults. The life cycle typically takes 2 to 4 years. Eggs hatch in the spring and larvae feed and molt to nymphs. Depending on the stage of development, ticks will overwinter as larvae or nymphs during the first 2 years and as adults in subsequent years. Diapause during the winter months is induced largely by short day length, although low temperature can also play a role.

Rhipicephalus sanguineus occurs throughout the entire region and is especially common in urban areas with high populations of dogs. The bionomics of the brown dog tick is discussed in greater detail in the section on boutonneuse fever. A complete list of North African tick species and their distributions appears in Appendix A.3.

Vector Surveillance and Suppression. There are several methods that can be used to determine the numbers and species of ticks in a given area. These include dragging a piece of flannel cloth over vegetation where ticks are waiting for a passing host and collecting the ticks that attach to the cloth, collecting ticks from animal hosts or their burrows/nests, attracting ticks to a trap using carbon dioxide (usually in the form of dry ice), and removing ticks from a person walking in a prescribed area. Different species and life stages of ticks are collected disproporti onately by the various methods, and techniques selected must be tailored to the species and life stage desired. These collection procedures are discussed thoroughly in TIM 26, Tick -borne Diseases: Vector Surveillance and Control.

Habitat modification can reduce tick abundance in limited areas. Mechanical removal of leaf litter, underbrush, and low-growing vegetation reduces the density of small mammal hosts and deprives ixodid ticks of the structural support they need to contact hosts. Leaf litter also provides microhabitats with environmental conditions suitable for survival, such as high relative humidity. Controlled burning, where environmentally acceptable, has been shown to reduce tick populations for 6 to 12 months.

Large-scale application of pesticides to control ticks is usually impractical and may be environmentally unacceptable at military installations during peacetime. Chemical treatment should be confined to intensely used areas with a high risk of tick -borne disease. Liquid formulations of pesticides can be applied to vegetation at various heights to provide immediate reduction in tick populations. Granular formulations provide slower control and only affect ticks at ground level. Both formulations give approximately the same level of control when evaluated over a period of several weeks. Consult TIMs 24 and 26 for specific pesticide recommendations and application techniques.

Exclusion of deer and other large animals using electric or nonelectric fences has reduced populations of *Ixodes* ticks that require large animals to complete their life cycle. This technique would have limited applicability in most military situations.

The **personal protective measures** discussed in TIMs 26 and 36 are the best means of protecting individual soldiers from tick bites. Clothing impregnated with permethrin is particularly effective against crawling arthropods like ticks. Frequent body checks while operating in tick-infested habitat are essential. Tick attachment for several hours is required for transmission of many tick-borne pathogens, so early removal of ticks can prevent infection (Appendix F).

The FDA has approved LYMErix, a vaccine developed by SmithKline Beecham, for vaccination of people ages 15 to 70. The vaccine is only about 80% effective, and it takes 3 shots over a full year to build optimal immunity. It protects only against North American strains of *B. burgdorferi* and is not effective against European genotypes of the spirochete. Therefore, vaccinated individuals must still use **personal protective measures** against ticks.

VII. Other Diseases of Potential Military Significance.

A. Leptospirosis. (Weil disease, Canicola fever, Hemorrhagic jaundice, Mud fever, Swineherd disease)
The spirochete bacterium *Leptospira interrogans* is the causative agent of this zoonotic disease. More than 200 serovars of *L. interrogans* have been identified, and these have been classified into 23 serogroups based on serological relationships. Common clinical features are fever with sudden onset, headache, and severe muscle pain. Serious complications can occur. The severity of leptospirosis varies greatly and is determined to a large extent by the infecting strain and health of the individual. In some areas of enzootic leptospirosis, a majority of infections are mild or asymptomatic. The incubation period is 10 to 12 days after infection.

Disease Distribution. Distribution is worldwide in urban and rural areas of both developed and developing countries. Leptospirosis is regarded as focally enzootic throughout North Africa.

Transmission Cycle(s). Numerous wild and domestic animals act as reservoirs, including rodents, raccoons, deer, squirrels, swine, cattle, sheep, goats, horses, and dogs. Because of its prevalence in rodents and domestic animals, leptospirosis has been primarily an occupational hazard to farmers, sewer workers, veterinarians, animal husbandry workers, and rice and sugarcane field workers. *Leptospira* infects the kidneys and is transmitted in the urine of infected animals. Humans become infected through contact of skin or mucous membranes with contaminated water, moist soil or vegetation. *Leptospira* survives only in fresh water. Spirochetes are not shed in the saliva; therefore, animal bites are not a source of infection. Although infected humans shed *Leptospira* in urine, person-to-person transmission is rare. Infection may occasionally occur by ingestion of food contaminated with urine from infected rats.

Disease Prevention and Control. To prevent leptospirosis, control domestic rodents around living quarters and food storage and preparation areas. *Leptospira* are readily killed by detergents, desiccation, acidity, and temperatures above 60 ^{o}C. Good sanitation reduces the risk of infection from commensal rodents. Troops should be educated about modes of transmission and instructed to avoid swimming or wading in potentially contaminated waters. Vaccines have been used effectively to protect workers in veterinary medicine, and immunization has also been used to protect against occupational exposure to specific serovars in Japan, China, Italy, Spain, France, and Israel. Short-term prophylaxis may be accomplished by administration of antibiotics. Doxycycline was effective in Panama in preventing leptospirosis in military personnel.

B. Hantaviral Disease. [Epidemic hemorrhagic fever, Korean hemorrhagic fever, Nephropathia epidemica, Hemorrhagic nephrosonephritis, Hemorrhagic fever with renal syndrome (HFRS)]
Hantaviruses are a closely related group of zoonotic viruses that infect rodents. They cause disease syndromes in humans that vary in severity but are characterized by abrupt onset of fever, lower back pain, and varying degrees of hemorrhagic manifestations and renal involvement. Severe illness is associated with Hantaan virus, primarily in Asia and the Balkans. The case fatality rate is variable but is about 5% in Asia and somewhat higher in the Balkans. Convalescence takes weeks to months. A less severe illness caused by Puumala virus and referred to as nephropathia epidemica predominates in Europe. Dobrava virus (Belgrade) has caused severe HFRS cases in several countries surrounding Turkey.

Military Impact and Historical Perspective. Prior to World War II, Japanese and Soviet authors described HFRS along the Amur River in Manchuria. In 1951, HFRS was recognized among United Nations troops in Korea and has been observed in both military personnel and civilians since then. Hantaan virus disease is considered an emerging health problem in many areas of the world. In 1993, an outbreak of disease caused by a new hantavirus occurred in the USA, but the target organs were the lungs rather than the kidneys. Advanced diagnostic techniques have led to increasing recognition of new hantaviruses and hantaviral infections globally. The military threat of hantaviruses is limited in North Africa since they have not been implicated in human disease in the

region. However, very few studies have been conducted on the epidemiology of hantaviruses in North Africa.

Disease Distribution. Hantaan virus claims 40,000 to 100,000 victims annually in China. South Korea has reported about 1,000 cases annually in recent years. Puumala virus circulates in European countries, Russia west of the Ural Mountains, and the Balkans. During the 1990s, outbreaks of Dobrava virus have been reported from Albania, Greece, and Bosnia and Herzegovina. Hantaviral antibodies have been detected in human and animal sera from Algeria and Egypt, but no clinical cases of disease have been reported. Hantavirus may infect rodents in seaports that are regularly visited by ships crewed by Asians from endemic areas.

Transmission Cycle(s). Virus is present in the urine, feces and saliva of persistently infected asymptomatic rodents. Aerosol transmission to humans from rodent excreta is the presumed mode of infection. Hantaan virus is commonly associated with the field mouse, *Apodemus agrarius*, in open field or unforested habitats. The red bank vole, *Clethrionomys glareolus*, inhabits woodland or forest-steppe environments and is a primary reservoir for Puumala virus. Dobrava virus has been isolated from the yellow-necked field mouse, *Apodemus flavicollis*. The risk of transmission is highest in warm months when rodent reservoir populations are abundant. Military personnel are exposed to infection when working, digging or sleeping in fields infested by infected rodents.

Disease Prevention and Control. Exclude or prevent rodent access to buildings. Store food in rodent-proof containers or buildings. Disinfect rodent-contaminated areas with diluted bleach or other antiviral agents. Do not sweep or vacuum rodent-contaminated areas; use a wet mop moistened with disinfectant. Eliminate wild rodent reservoirs before military encampments are established in fields. Detailed information on surveillance and personal protective measures when working around potentially infected rodents can be found in TIM 40, Methods for Trapping and Sampling Small Mammals for Virologic Testing, and in TIM 41, Protection from Rodent-borne Diseases.

VIII. Noxious/Venomous Animals and Plants of Military Significance.

A. Arthropods.

Annoyance by biting and stinging arthropods can adversely affect troop morale. The salivary secretions and venoms of arthropods are complex mixtures of proteins and other substances that are allergenic. Reactions to arthropod bites and stings range from mild local irritation to systemic reactions causing considerable morbidity, including rare but life-threatening anaphylactic shock. Insect bites can be so severe and pervasive that they affect the operational readiness of troops in the field. Bites and their discomfort have been a major complaint by soldiers deployed in many regions of the world.

Entomophobia, the irrational fear of insects, and the related arachnophobia, fear of spiders, are two of the most common human phobias. The anxiety produced in a fearful individual by a potential encounter with an insect range from mild aversion to panic. The degree of negative response to encounters with insects or spiders is important in

accessing the difference between common fear and true phobia. Common fear is a natural extension of human experience that is appropriate to situations that involve potential danger or require caution. Phobias however, are characterized by persistent, high levels of anxiety in situations of little to no threat to the individual. Many individuals may express a fear of insects or spiders, but few are phobic to the extent that their ability to function in a normal daily routine is impaired by their fear. The term delusory parasitosis refers to a mental disorder in which an individual has an unwarranted belief that insects or mites are infesting his or her body or environment. This p sychiatric condition is distinct from entomophobia or an exaggerated fear of real insects. Extreme entomophobia and delusory parasitosis require psychological treatment.

The following groups of noxious arthropods are those most likely to be encountered by military personnel operating in countries of North Africa:

1. Acari (ticks and mites). Tick paralysis is a potentially fatal but easily cured affliction of man and animals. It is almost exclusively associated with hard (ixodid) ticks and is caused by injection of neurotoxin(s) in tick saliva. The toxin, which may be different in different species, disrupts nerve synapses in the spinal cord and blocks the neuromuscular junctions. Worldwide, nearly 50 species of hard ticks have been associated with ti ck paralysis, although any ixodid tick may be capable of producing this syndrome. A tick must be attached to its host for 4 to 6 days before symptoms appear. This condition is characterized by an ascending, flaccid paralysis, usually beginning in the leg s. Progressive paralysis can lead to respiratory failure and death. Diagnosis simply involves finding the embedded tick, usually at the base of the neck or in the scalp. After tick removal, symptoms resolve within hours or days. However, if paralysis i s advanced, recovery can take several weeks. No drugs are available for treatment. Several species of ticks known to cause tick paralysis are widely distributed in North Africa, including *Dermacentor marginatus*, *Haemaphysalis punctata*, *Hyalomma truncatum* and *Ixodes ricinus*.

Most tick bites are painless, produce only mild local reaction, and frequently go unnoticed. However, inflammation or even hypersensitivity reactions may occur within a few days of tick attachment. After tick removal, a reddened no dule may persist for weeks or months. The bite of the cave tick, *Ornithodoros tholozani*, produces deep red, crusted nodules or papules up to 1.5 cm in diameter. Tick toxicosis is a systemic reaction to tick saliva. In Israel, *Ixodes redikorzevi* causes toxicosis in humans characterized by swelling at the point of attachment, regional lymphadenopathy and, sometimes, fever. The symptoms disappear 1 to 2 days after removal of the tick. Tickbite anaphylaxis has rarely been reported, but studies in Australia suggest it is more common and potentially life threatening than tick paralysis. Tick removal and other personal protective measures against ticks are discussed in Appendix F.

Scabies is the most important disease caused by mite infestation, and infestations have been common during military conflict. During World War I, scabies infestations occurred at a rate of 20 per 1,000 soldiers per year among American forces in Europe. During World War II, nearly 100,000 cases were r eported in American troops. Five

percent of the residents of London became infested with scabies during the bombing of the city by the German Air Force. During the Falklands War of 1982, scabies became such a problem among Argentine troops that their fighting efficiency was significantly impaired.

Sarcoptes scabiei (family Sarcoptidae) is a parasitic mite that spends its entire life cycle in burrows in the skin of mammals. Mite infestations cause scabies in man and mange in other animals, including primates, horses, wild and domestic ruminants, pigs, camels, rabbits, dogs and other carnivores. Populations found on different host species differ physiologically more than morphologically and are referred to as forms (those on man, for instance, is *S. scabiei* form *hominis*). All forms are considered to be the same species, *Sarcoptes scabiei*, but scabies mites from one host species do not establish themselves on another. Humans can become infested with scabies mites from horses or dogs, but such infestations are usually mild and disappear without treatment. *Sarcoptes* mites are common on domestic animals in North Africa, and troops should avoid contact with local animals.

Scabies mites are very small, about 0.2 to 0.4 mm. Both sexes burrow in the horny layer of the skin, but only the female makes permanent winding burrows parallel to the skin surface. The female lays a few eggs in the burrow. The six-legged larvae that hatch from the eggs leave the burrow and move to the hair follicles. Two nymphal stages that precede the adult are also found in the hair follicles. The entire life cycle takes 10 to 14 days. Scabies is transmitted from person to person by close, prolonged personal contact. Transmission is common in dormitories, barracks and medical facilities. Mites die rapidly away from the human body.

Most mite burrows occur in the interdigital and elbow skin, but skin of the scrotum, breasts, knees and buttocks is also affected. The face and scalp are rarely involved. In newly infested persons, a period of 3 to 4 weeks usually elapses before sensitization to mites and mite excretions develops. Itching is not experienced during this period, and infestations may progress extensively before being noticed. However, fewer than 20 mites are enough to produce intense itching, particularly at night. The burrows often become secondarily infected with bacteria. In infested persons, an extensive rash can cover areas where there are no mites. In immunocompromised individuals, who do not respond to infestation by itching and scratching, mites can reach very high populations and produce a scaly crusted skin known as Norwegian scabies.

Sarcoptes scabiei is cosmopolitan and common in North Africa. An epidemiological study of scabies infestation in the Egyptian village of Mit-Moaned, Dakahlia Governorate, detected a prevalence rate of 5%. Scabies is not a reportable disease in most countries; thus, estimated rates of infestation are usually inaccurate. Scabies is usually only reported when large outbreaks occur. Increases in the incidence of scabies appear to occur in 15 to 20 year cycles that are related to fluctuating levels of immunity to *S. scabiei* in the human population.

Persons of all ages are affected, although in most developing countries infestation is highest in poor communities and in children. Infestation is more common in overcrowded areas with poor hygiene. A 1993 study found 77% of infested patients treated at the Ain Shams University Hospital in Cairo lived in overcrowded slums and bathed infrequently.

2. Araneae (spiders). More than 35,000 species of spiders have been described worldwide. All spiders, with the exception of the family Uloboridae, are venomous and use their venom to immobilize or kill prey. Most spiders are harmless because their chelicerae cannot penetrate human skin, or they have venom of low toxicity to humans. Only about a dozen species have been responsible for systematic severe envenomization in humans, although as many as 500 may be capable of inflicting significant bites. Those that can bite humans are rarely seen or recovered for identification, so physicians need to be able to recognize signs and symptoms of common venomous spider bites in order to administer appropriate therapy. In North Africa the widow spiders, *Lactrodectus* spp., and the sac spiders, *Chiracanthium* spp., are responsible for significant local and systemic effects from envenomization.

Several species of widow spiders occur in North Africa, but *Latrodectus mactans* is the one most associated with the name "black widow spider". It is also referred to as the hourglass, shoe button, or po-ko-moo spider. Considerable variation in coloration and markings exists between species and between immature and adult spiders. Widow spiders are found in various habitats in the wild, especially in protected places such as crawl spaces under buildings, holes in dirt embankments, piles of rocks, boards, bricks or firewood. Indoors, they prefer dark areas behind or underneath appliances, in deep closets and cabinets. They commonly infest outdoor privies, and preventive medicine personnel should routinely inspect these structures. Widow spiders spin a crude web and usually will not bite unless provoked.

Latrodectus spp. inject a potent neurotoxin when biting. The bite itself is mild and most patients don't remember being bitten. Significant envenomization results in severe systemic symptoms, including painful muscle spasms, a rigid board-like abdomen, and tightness in the chest. Mortality rates from untreated bites have been estimated at 1 to 5%. Most envenomizations respond quickly to sustained intravenous calcium gluconate. Antivenins are commercially available and very effective.

Steatoda nobilis belongs to the same family as *Latrodectus* spp., and its neurotoxic venom produces significant local and systemic symptoms. This species is common in the Canary Islands.

Sac spiders of the genus *Chiracanthium* have a cytolytic venom that produces cutaneous necrosis in its victims, although the necrotizing lesions are usually not as severe as those produced by the bite of *Loxosceles* spp. *Chiracanthium mildei* is a common species indigenous to North Africa. This spider is 7 to 10 mm in length, and it has a pale-brown cephalothorax and white abdomen. It adapts well to homes and other buildings.

3. Ceratopogonidae (biting midges, no-see-ums, punkies). The Ceratopogonidae is a large family containing nearly 4,000 species. These extremely small flies can easily pass through window screens and standard mosquito netting, although most species feed primarily outdoors. Their small size is responsible for the moniker "no-see-ums." Many species in this group attack and suck fluids from other insects. Most species that suck vertebrate blood belong to the genera *Culicoides* (1,000 species) or *Leptoconops* (about 80 species). In North Africa these insects do not transmit human diseases, but they do serve as vectors for several diseases of veterinary importance. Many species of Ceratopogonidae are widespread in the region, but little is known about their biology. Most North African species of *Culicoides* are zoophilic. *Leptoconops* are more likely to be a major nuisance to man. Blood-sucking species predominately feed and rest outdoors, entering houses in much smaller numbers. Only females suck blood. *Leptoconops* are active during the day; *Culicoides* may be either diurnal or nocturnal. Diurnal species of both genera prefer early morning and late afternoon periods. Despite their small size, they often cause local reactions severe enough to render a military unit operationally ineffective. In sensitive people bites may blister, exude serum, itch for several days, or be complicated by secondary infections from scratching. Enormous numbers of these tiny flies often emerge from breeding sites, causing intolerable annoyance.

Breeding habits vary widely from species to species. The larvae are primarily aquatic or semiaquatic, occurring in the sand or mud of fresh, salt, or brackish water habitats, notably salt marshes and mangrove swamps. Many species exploit specialized habitats such as tree holes, decaying vegetation, and cattle dung. Most species remain within 500 m of their breeding grounds. Ceratopogonidae are troublesome mainly under calm conditions; their number declines rapidly with increasing wind speed. In militarily secure areas, encampments should be located in the open, away from breeding sites, to avoid the nuisance caused by these insects.

Larvae are difficult to find, but adults are easily collected while biting and with light traps. Environmental management best controls larval stages, but this may be impractical. Adult control typically includes applying residual insecticides to fly harborages, treating screens and bednets with pyrethroids, and using repellents.

4. Chilopoda (centipedes) and Diplopoda (millipedes). Centipedes in tropical countries can attain considerable size. Members of the genus *Scolopendra* can be over 25 cm long and are capable of inflicting painful bites, with discomfort lasting 1 to 5 hours. Several species of this genus known to bite man are very common in North Africa. Two puncture wounds at the site of attack characterize the bite. Neurotoxic and hemolytic components of a centipede's venom normally produce only a localized reaction, but generalized symptoms such as vomiting, irregular pulse, dizziness and headache may occur. Most centipede bites are uncomplicated and self-limiting, but secondary infections can occur at the bite site. Centipede bites are rarely fatal to humans.

Centipedes are flattened in appearance and have one pair of legs per body segment. Large species may have over 100 pairs of legs. They are fast moving, nocturnal

predators of small arthropods. During the day, they hide under rocks, boards, bark, stones and leaf litter, but occasionally they find their way into homes, buildings, and tents. Most centipede bites occur when the victim is sleeping or when putting on clothes in which centipedes have hidden. Troops should be taught to inspect clothing and footwear when living in the field.

Millipedes are similar to centipedes except that they have two pairs of legs per body segment and are rounded or cylindrical instead of flattened. Millipedes are commonly found under stones, in soil and in leaf litter. They are nocturnal and feed on decaying organic matter. They are more abundant during the wet season. When disturbed they coil up into a tight spiral. Millipedes do not bite or sting, but some species secrete defensive body fluids containing quinones and cyanides that discolor and burn the skin. An initial yellowish-brown tanning turns to deep mahogany or purple-brown within a few hours of exposure. Blistering may follow in a day or two. Eye exposure may require medical treatment. A few species from the genera *Spirobolida*, *Spirostreptus*, and *Rhinocrichus* can squirt their secretions a distance of 80 cm or more.

5. Cimicidae (bed bugs). There are over 90 species in the family Cimicidae. Most are associated with birds and/or bats and rarely bite humans. The common bed bug, *Cimex lectularis*, has been associated with humans for centuries and is cosmopolitan in distribution. The tropical bed bug, *Cimex hemipterus*, also feeds on humans and is similar in appearance to *C. lectularis*. It is common in tropical areas of Asia, Africa and Central America. Bed bug infestations are typical of unsanitary conditions, but they can still be found in developed countries. There is little evidence that bed bugs transmit any pathogens. Bites can be very irritating, prone to secondary infection after scratching, and may produce hard swellings or welts. Bed bugs feed at night while their hosts are sleeping but will feed during the day if conditions are favorable. During the day they hide in cracks and crevices, under mattresses, in mattress seams, spaces under baseboards, or loose wallpaper. Chronic exposure to bed bugs can result in insomnia, nervousness and fatigue. A study in Cairo found a high percentage of asthmatic patients had positive skin reactions to *Cimex* antigen.

Five nymphal instars precede the adult stage. Each nymph must take a bloodmeal in order to molt. Adults live up to one year. Bed bugs take about five minutes to obtain a full bloodmeal. They can survive long periods of time without feeding, reappearing from their hiding places when hosts become available. Bed bugs possess scent glands and emit a characteristic odor that can easily be detected in heavily infested areas. Blood spots on bedding or "bedclothes" and fecal deposits are other signs of infestation.

Bed bugs are common in some areas of North Africa. They can be introduced into barracks through infested baggage and belongings. In contingency situations, old dwellings should be surveyed for these and other pests before they are occupied.

6. Dipterans Causing Myiasis. Myiasis refers to the condition of fly maggots infesting the organs and tissues of people or animals. Specific cases of myiasis are clinically defined by the affected organ, e.g., cutaneous, enteric, rectal, aural, urogenital, ocular,

etc. Myiasis can be accidental when fly larvae occasionally find their way into the human body. Accidental enteric myiasis occurs from ingesting fly eggs or young maggots on uncooked foods or previously cooked foods that have been subsequently infested. Other cases may occur from the use of contaminated catheters, douching syringes, or other invasive medical equipment in field hospitals. Accidental enteric myiasis is usually a benign event, but larvae may survive temporarily, causing stomach pains, nausea, or vomiting. Numerous fly species in the families Muscidae, Calliphoridae, and Sarcophagidae are involved in accidental enteric myiasis. A common example is the cheese skipper, *Piophila casei* (family Piophilidae), which infests cheese, dried meats and fish.

Facultative myiasis occurs when fly larvae infest living tissues opportunistically after feeding on decaying tissues in neglected wounds. Considerable pain and injury may be experienced as fly larvae invade healthy tissues. Facultative myiasis has been common in wounded soldiers throughout military history, and numerous species of Muscidae, Calliphoridae, and Sarcophagidae have been implicated. Species of these families are widespread throughout North Africa.

Myiasis is obligate when fly larvae must develop in living tissues. This constitutes true parasitism and is essentially a zoonosis. Obligate myiasis is a serious pathology. In humans, obligate myiasis results primarily from fly species that normally parasitize domestic and wild animals. The sheep bot fly, *Oestrus ovis*, is widespread in North African countries, including the Canary Islands. Larvae are obligate parasites in the nostrils and frontal sinuses of sheep, goats, camels and horses. Human ocular infestation by *O. ovis* is not uncommon, and several cases occurred in US military personnel during the Persian Gulf War. Female flies are larviparous, depositing larvae while in flight directly into the human eye. Normally, infestations produce a painful but not serious form of conjunctivitis. However, larvae are capable of penetrating to the inner eye, causing serious complications.

The Tumbu fly, *Cordylobia anthropophaga*, is a blow fly (family Calliphoridae), whose larvae can burrow into human subcutaneous tissue, producing a boil-like lesion. Larvae develop in the subcutaneous tissue for about 10 days, then exit the wound and pupate in the ground. Dogs are the most common domestic host, and several species of wild rats are the preferred field hosts. Tumbu flies do not lay eggs directly on the skin or hairs of a host; rather females oviposit in sand that has been contaminated by urine or feces. Thus, soiled clothing may stimulate oviposition. Larvae remain in the sand or soil until a host approaches. Tumbu flies are a common parasite of tropical Africa and were once restricted to the sub-Saharan region, but they have been recorded in southwestern Saudi Arabia since 1980 and could spread to North African countries. A Tumbu fly infestation occurred in a US Marine sergeant during Operation Restore Hope in Somalia.

Wohlfahrtia magnifica (family Sarcophagidae) is an important obligatory parasite in the wounds and natural orifices of warm-blooded animals, including humans. Cases of myiasis caused by this species have been reported from Egypt. Ophthalmic and nasal myiases caused by the Old World screwworm fly, *Chrysomyia bezziana*, have been

reported from northern Algeria, although this species is not indigenous to North Africa. The New World screwworm, *Cochliomyia hominivorax*, was detected in Libya in 1988 and is a serious pest of livestock. This species caused several cases of human myiasis before it was eradicated from Libya in the early 1990s.

Myiasis is rarely fatal, but troops living in the field during combat are at a high risk of infestation. Good sanitation can prevent most cases of accidental and facultative myiasis. To prevent flies from ovipositing on them, exposed foodstuffs should not be left unattended. Fruits and vegetables should be washed prior to consumption and examined for developing maggots. Extra care should be taken to keep wounds clean and dressed. Avoid sleeping in the nude, especially outdoors during daytime when adult flies are active and likely to oviposit in body orifices. At field facilities, proper waste disposal and fly control can reduce fly populations and the risk of infestation.

7. Hymenoptera (ants, bees, wasps). Most wasps and some bees are solitary or subsocial insects that use their stings for subduing prey. These species are not usually involved in stinging incidents, and their venom generally causes only slight and temporary pain to humans. The social wasps, bees and ants use their sting primarily as a defensive weapon, and their venom causes intense pain in vertebrates.

The three families of Hymenoptera responsible for most stings in humans are the Vespidae (wasps, hornets, and yellow jackets), the Apidae (honey bees and bumble bees), and the Formicidae (ants). Wasps and ants can retract their stings after use and can sting repeatedly. The honey bee stinging apparatus has barbs that hold it so firmly that the bee's abdomen ruptures when it tries to pull the stinger out of the skin. The bee's poison gland, which is attached to the stinger, will continue injecting venom after separation. Scraping the skin after a bee sting is important to remove the stinger and attached venom sac. Honey bees are the most common source of stings in North Africa. Wild strains of honey bees can be very aggressive. The hornet, *Vespa orientalis*, is common around freshwater habitats and is responsible for many stinging incidents in Egypt. Ants can bite, sting and squirt formic acid. Some protein-feeding ants such as the pharaoh ant, *Monomorium pharaonis*, have been incriminated as mechanical vectors of pathogens in hospitals.

Hymenoptera venoms have not been fully characterized but contain complex mixtures of allergenic proteins and peptides as well as vasoactive substances, such as histamine and norepinephrine. There is no allergic cross-reactivity between honey bee and vespid venoms, although cross-reactivity may exist to some extent between different vespid venoms. Therefore, a person sensitized to one vespid venom could have a serious reaction to the sting of another member of the vespid family.

Reactions to stings may be grouped into two categories, immediate (within two hours) or delayed (more than two hours). Immediate reactions are the most common and are subdivided into local, large local or systemic allergic reactions. Local reactions are nonallergic responses characterized by erythema, swelling, and transient pain at the sting site that subsides in a few hours. Stings in the mouth or throat may require medical

assistance. Multiple stings in a short period of time may cause systemic symptoms such as nausea, malaise and fever. It generally takes 500 or more honey bee stings to kill an adult by the toxic effects of the venom alone. Large local reactions are characterized by painful swelling at least 5 cm in diameter and may involve an entire extremity. Systemic reactions vary from mild urticaria to more severe reactions, including vomiting, dizziness and wheezing. Severe allergic reactions are rare but can result in anaphylactic shock, difficulty in breathing, and death within 30 minutes. Emergency kits should be provided to patients who have experienced anaphylactic reactions to stings. Commercial kits are available that include antihistamine tablets and syringes preloaded with epinephrine. Sensitive individuals should also consider wearing a Medic-Alert tag to alert medical personnel of their allergy in case they lose consciousness. Venom immunotherapy for sensitive individuals will reduce but not eliminate the risk of anaphylactic reactions.

Delayed reactions to Hymenoptera envenomization is uncommon but usually presents as a large local swelling or, rarely, as systemic syndromes. The cause of delayed reactions is unclear and may not always involve immunologic mechanisms.

Individuals can practice a number of precautions to avoid stinging insects. Avoid wearing brightly colored floral-pattern clothes. Do not go barefoot in fields where bees and wasps may be feeding at ground level. Avoid the use of scented sprays, perfumes, shampoos, suntan lotions, and soaps when working outdoors. Be cautious around rotting fruit, garbage cans, and littered picnic grounds, since large numbers of yellow jackets often feed in these areas. Avoid drinking sodas or eating fruits and other sweets outdoors, since bees and yellow jackets are attracted to these items. Bees and wasps are most aggressive around their nests, which should not be disturbed.

8. Lepidoptera (urticating moths and caterpillars). The caterpillars of certain moths possess urticating hairs that can cause dermatitis. The hairs are usually connected to glands that release poison when the hair tips break in human skin. The intensity of the irritation varies with the species of moth and the sensitivity of the individual, but usually the symptoms are temporary. Hairs stimulate the release of histamine, and resultant skin rashes last about a week. The irritation is more severe when the hairs reach mucous membranes or the eye, where they can cause nodular conjunctivitis. Urticating hairs can also become attached to the cocoon when the larva pupates, and later to the adult moth. Hairs readily become airborne. If inhaled, detached caterpillar hairs can cause labored breathing; if ingested, they can cause mouth irritation. The hairs of some species retain their urticating properties long after being shed. Hairs and setae may drop into swimming pools and irritate swimmers. Acute urticarial lesions usually respond to topical corticosteroid lotions and creams, which reduce the inflammatory reaction. Oral histamines help relieve itching and burning sensations.

Larvae of *Thaumetopoea* spp. (processionary moths, Thaumetopoeidae) are common in the Mediterranean, although contact dermatitis from moth hairs is a limited public health problem in North Africa.

9. Meloidae (blister beetles) and Staphylinidae (rove beetles). Blister beetles are moderate-sized (10 to 25 mm in length), soft -bodied insects that produce cantharidin in their body fluids. Cantharidin is a strong vesicant that readily penetrates the skin. Handling or crushing the beetles causes blistering within a few hours of skin contact. Blisters are generally not serious and normally clear within 7 to 10 days. If blister beetles are ingested, cantharidin can cause nausea, diarrhea, vomiting, and abdominal cramps. Blisters that occur on the feet where they will be rubbed may need to be drained and treated with antiseptics. Cantharidin was once regarded as an aphrodisiac, and a European species of blister beetle was popula rly known as Spanish-fly. Troops should be warned against using blister beetles for this purpose, since cantharidin is highly toxic when taken orally.

The Staphylinidae, commonly called rove beetles, is another family that produces a strong vesicating substance that causes blistering. Rove beetles are active insects that run or fly rapidly. When running, they frequently raise the tip of the abdomen, much as scorpions do. They vary in size, but the largest are about 25 mm in length. Some of the larger rove beetles can inflict a painful bite when handled. Many species are small (<5 mm) and can get under clothing or in the eyes. Members of the genus *Paederus* are widespread throughout the world. They have a toxin, pederin, that can cause dermatitis and a painful conjunctivitis and temporary blindness after eye contact. Normally, rove beetles must be crushed to release the vesicating agent. Like beetles in the family Meloidae, rove beetles are attracted to light and can be a hazard to soldiers at guard posts. Rove beetles often emerge in large numbers after rains and can cause outbreaks of dermatitis. A 1966 outbreak of blistering on Okinawa resulted in 2,000 people seeking medical treatment. *Paederus alfierii* has caused outbreaks of dermatitis and conjunctivitis in Egypt.

10. Scorpionida (scorpions). These arthropods have a stout cephalothorax, 4 pairs of legs, a pair of large anterior pedipalps with enlarged claws, and a tail tipped with a bulbous enlargement and a poisonous stinger. Some species carry the tail above the dorsum of the thorax, while others drag it behind. Of over 1,500 described species worldwide, fewer than 25, all in the family Buthidae, possess a venom that is life threatening to humans. Scorpions inject the venom with a sting er on the tip of their abdomen, and some species can inflict a painful pinch with their pedipalps. They feed at night on insects, spiders and other arthropods. During the daytime, scorpions hide beneath stones, logs or bark, loose earth or among manmade o bjects. In dwellings, scorpions frequently rest in shoes or clothing.

There is a broad array of scorpions in North Africa. The two most widely distributed species of medical importance are the yellow scorpion, *Leiurus quinquestriatus,* and the black scorpion, *Androctonus crassicauda*. A list of species reported from North Africa appears in Appendix A.5.

Most stings are to the lower extremities or the arms and hands. Among indigenous populations, stings are more oft en inflicted at night, while scorpions are most actively

hunting for prey. While scorpion stings can occur year-round in North Africa, most are reported during the warmer months of April to August.

In Tunisia and Algeria, *Androctonus australis*, *A. aeneas*, and *Buthus occitanus* are the three most important species, frequently causing death in young children or elderly people. Urbanization seems to have extended the range of *A. australis* northward. *Scorpio maurus*, while common, is not dangerous. In Morocco, the two most dangerous scorpions are *A. amoreuxi*, found in the desert, and *A. mauretanicus*, in the inhabited plains. In Libya, the five most dangerous species are *A. amoruexi*, *A. australis*, *B. arenicola*, *B. leiurus* and *B. occitanus tunetanus*. In southern Egypt, *B. minax* is a very venomous scorpion causing neurotoxicity among residents along the Nile River. Based on distribution information, it is estimated that *A. amoreuxi*, *A. australis*, *B. occitanus tunetanus*, and *L. quinquestriatus* are also frequently involved in scorpion envenomization cases in Egypt.

Scorpions can sting multiple times, and when trapped, as with a person in a sleeping bag, will readily do so, as long as the victim is active. Common places where stings are encountered by military personnel include the boots and under or around piled clothing. Scorpion stings broadly affect nearly all body tissues, and they present a mixture of hemolytic, neurotoxic and cardiotoxic effects. All stings should be considered potentially dangerous. The severity of scorpion stings can be categorized as follows: 1) patients with pain, but no systemic findings; 2) those who, in addition to pain, have one or two mild systemic manifestations, such as local muscle spasm, dry mouth, increased salivation, or runny nose; 3) those who have more severe systemic manifestations but no central nervous system manifestation or general paralysis; and 4) those who have severe systemic reactions, including central nervous system involvement, such as confusion, convulsions, and coma, with or without general paralysis. They may also develop uncoordinated eye movements, penile swelling, or cyanosis. The most severe manifestations occur in children, who are more susceptible to the effects of venom because of their small body mass. Those with type 1, 2, or 3 manifestations can be managed by attempting to slow the spread of the venom by applying ice, and supporting the patient with fluids and antihistamines. However, those with type 4 manifestations require intensive medical treatment, especially during the first 24 hours following the sting. Antivenin therapy is important for severe cases. For this treatment to be effective, the stinging scorpion must be captured so it can be properly identified.

To prevent scorpion stings, military personnel should be instructed to empty boots before attempting to put them on, carefully inspect clothing left on the ground before putting it on, and keep sleeping bags tightly rolled when not in use.

11. Simuliidae (black flies, buffalo gnats, turkey gnats). Black flies are small (3 to 5 mm), usually dark, stout-bodied, hump-backed flies with short wings. Despite their appearance, black flies are strong flyers that are capable of dispersing many km from their breeding sites. Only females suck blood. They can emerge in large numbers and be serious pests of both livestock and humans. Black flies bite during the day and in the open. Some species have a bimodal pattern of activity, with peaks of activity around

0900 h in the morning and 1700 h in the afternoon, but in shaded areas biting is more evenly distributed throughout the day. The arms, legs and face are common sites of attack, and a favorite site is the nape of the neck. Black fly bites may be itchy and slow to heal. Systemic reactions, characterized by wheezing, fever or widespread urticaria, are rare but require medical evaluation and treatment. Since black fly larvae require clean, flowing water, their distribution in North Africa is limited.

12. Siphonaptera (fleas). Fleabites can be an immense source of discomfort. The typical fleabite consists of a central spot surrounded by an erythematous ring. There is usually little swelling, but the center may be elevated into a papule. Papular urticaria is seen in persons with chronic exposure to flea bites. In sensitized individuals, a delayed papular reaction with intense itching may require medical treatment.

Fleas are extremely mobile, jumping as high as 30 cm. Biting often occurs around the ankles when troops walk through flea-infested habitat. Blousing trousers inside boots is essential to provide a barrier, since fleas will crawl under blousing garters. Fleas may be encountered in large numbers shortly after entering an abandoned dwelling. When a dwelling is abandoned, flea pupae will remain in a quiescent state for long periods of time. The activity of anyone entering such premises will stimulate a mass emergence of hungry fleas. The most common pest species of fleas encountered in North Africa are the cosmopolitan cat and dog fleas, *Ctenocephalides felis* and *C. canis*, the Oriental rat flea, *Xenopsylla cheopis*, and the human flea, *Pulex irritans*. A list of species reported from this region appears in Appendix A.4.

13. Solpugida (sun spiders, wind scorpions). These arthropods are common in arid environments of North Africa. They avoid oases and other fertile places, seeming to prefer utterly neglected regions where the soil is broken and bare. Their hairy, spider-like appearance and ability to run rapidly across the ground give rise to their common names. They range from 20 to 35 mm in body length and are usually pale colored. They have very large, powerful chelicerae, giving them a ferocious appearance. They can inflict a painful bite but do not have venom glands. Sun spiders are largely nocturnal, hiding during the day under objects or in burrows. They are aggressive and voracious predators on other arthropods. They easily kill scorpions and may even capture small lizards. At night they sometimes enter tents to catch flies or other insects.

14. Tabanidae (horse flies and deer flies). Tabanids are large, stout-bodied flies with well-developed eyes that are often brilliantly colored. More than 4,000 species have been described worldwide. The larvae develop in moist or semiaquatic sites, such as the margins of ponds, salt marshes or damp earth. The immature stages are unknown for most species. Mature larvae migrate from their muddy habitats to drier areas of soil to pupate. In temperate regions the entire life cycle can take two years or more to complete. The larvae of horse flies are carnivorous and cannibalistic, whereas deer fly larvae feed on plant material. Consequently, deer fly populations can reach considerably higher numbers in the same area. Deer flies, about 8 to 15 mm long, are about half the size of

horse flies, which range from 20 to 25 mm long. The most common tabanid genera containing man-biting species are *Chrysops* (deer flies), and *Tabanus* and *Haematopota* (horse flies).

Only female tabanids bite and take a blood meal, and nearly all species feed on mammals. Males feed on flower and vegetable juices. Tabanids are diurnal and are most active on warm, sunny days with low wind speeds, especially during the early morning and late afternoon. Adults are powerful flyers with a range of several km. They are very persistent biters, and their painful bites are extremely annoying. Tabanids lacerate the skin with scissor-like mouthparts and ingest the blood that flows into the wound. Some species can consume as much as 200 mg of blood. The puncture in the skin continues to ooze blood after the fly has fed. Tabanid bites often become secondarily infected, and systemic reactions may occur in hypersensitive individuals. The mouthparts and feeding behavior of tabanids are well suited to the mechanical transmission of blood-borne pathogens. Because their bites are painful, tabanids are frequently disturbed while feeding and move readily from host to host. In North Africa, tabanids are not vectors of human disease but are serious pests of livestock and transmit several diseases of veterinary importance.

Tabanids are difficult to control. Larval control is impractical, and ULV aerosols are generally ineffective against adults. Localized control can be achieved around military encampments using a variety of simple traps. The skin repellent DEET is only moderately effective against these flies.

B. Venomous Snakes of North Africa.

A wide variety of venomous terrestrial snakes inhabit North Africa, including representatives of four families: Atractaspidae, Colubridae, Elapidae and Viperidae.

Members of the Atractaspidae are burrowing vipers, also known as mole vipers or adders. Just one species, *Atractaspis engaddensis*, occurs in North Africa. This thin, plain-looking snake has little or no body pattern, a short cylindrical head (no wider than the body), underslung jaws, and extensible fangs. This is a nocturnal species that is normally not aggressive but is quick to bite if disturbed. Venom from these snakes produces severe hemorrhagic effects and systemic reactions, but death is rare.

Although most members of the family Colubridae are nonvenomous, there is one venomous species in North Africa: *Molopon monspessulanus* which possesses relatively small, grooved fangs in the rear of the upper jaw. This snake is rarely encountered, and little is known about the nature of its venom.

The family Elapidae contains four species of cobras native to North Africa. The snakes in this group are generally very active at night but rest during the day. They are widely known for lifting their body high off the ground and spreading their hoods in a defensive posture. The spitting cobra, *Naja nigricollis*, is notorious for expelling its venom toward the eyes of its victim, which causes severe pain and photophobia for 2 to 3 days. It can accurately expel its venom for a distance of about 2.5 meters. When injected, the venom

produces severe neurotoxic symptoms, including respiratory paralysis, convulsions, and sometimes death. *Naja haje*, the African banded cobra, often occupies abandoned rodent burrows. Its venom is highly neurotoxic and may cause respiratory paralysis and arrested heartbeat. *Naja mossambica* will also spit at its victims rather than bite. The venom is very toxic when it contacts the eyes. It prevents the victim from opening the eyes, causes copious tearing and, occasionally, blindness.

The desert blacksnake/cobra, *Walterinnesia aegyptia*, is a predominately black snake with relatively aggressive behavior. This species is a nocturnal hunter but spends most of its time underground. Because its hood is hardly noticeable, it is often not associated with the cobra family. Its neurotoxic venom contains an anticoagulant and is moderately dangerous.

Species of Viperidae are commonly known as vipers, adders, or asps. They have heavy, patterned bodies and triangle-shaped heads, sometimes with horns. They possess two relatively long, hollow fangs at the front of the upper jaw. These fangs are erected during a bite but are folded against the palate when the mouth is shut. Ten species of this family occur in North Africa. The common viper, *Cerastes vipera*, and the puff adder, *Bitis arietans*, are probably the best known species of this group. The puff adder is a relatively short but heavy-bodied snake, with a large triangle-shaped head. This snake is generally slow but bad-tempered. It can strike quickly when aroused. Puff adders can enlarge their body with air and hiss when excited. The venom of the common viper, *Cerastes vipera*, is the least toxic of this group. Viper species are nocturnal hunters but are frequently encountered during the day. They are slow moving but strike with accuracy and force when disturbed. The distribution of venomous terrestrial snakes in North Africa is shown in Table 1. Sources of snake antivenoms are listed in Appendix D.

For additional information on snakes and snakebite, contact the Armed Forces Medical Intelligence Center at Fort Detrick, MD. (301) 619-7574, DSN 343-7574; FAX (301) 619-2409 (DSN = 343). Also consult: Management of Snakebite in the Field, by LTC Hamilton.

Table 1. Distribution of Venomous Terrestrial Snakes in North Africa

Snake Species	Algeria	Egypt	Libya	Morocco	Tunisia
ATRACTASPIDAE					
Atractaspis microlepidota		+			
COLUBRIDAE					
Malpolon monspessulanus	+	+	+	+	+
ELAPIDAE					
Naja haje	+	+	+	+	+
N. pallida		+			
Walterinnesia aegyptia		+			
VIPERIDAE					
Bitis arietans	+			+	
Cerastes cerastes	+	+	+	+	+
C. vipera	+	+	+	+	+
Echis coloratus		+			
E. leucogaster	+			+	
E. pyramidium	+	+	+	?	+
Macrovipera deserti	+		+		+
M. lebetina	+				+
M. mauritanica	+			+	+
Pseudocerastes persicus		+			
Vipera latastei	+			+	+
V. monticola				+	

C. Medical Botany.

1. Plants that Cause Contact Dermatitis.

Plant dermatitis is a problem of enormous magnitude. Categor ies of dermal injury caused by plants include mechanical injury, delayed contact sensitivity, contact urticaria, phototoxicity and photoallergy, primary chemical irritation, or some combination of these. Plants causing contact dermatitis in North Africa a re listed in Table 2.

Mechanical injury by splinters, thorns, spines, and sharp leaf edges can produce visual impairment or fungal and bacterial infections at the site of injury.

Members of the *Rhus* group (poison ivy, oak, and sumac) are the most frequent causes of acute allergic contact dermatitis. A large portion of the US population is sensitive to urushiol in the sap of these plants. Sensitivity to a substance develops after initial cutaneous contact. Once sensitized, subsequent exposure will elicit an allergic response in which the whole body surface becomes reactive. Even smoke from burning plants can

produce an allergic response. Barrier creams have been developed to prevent contact dermatitis in people sensitive to urushiol.

Contact urticaria may result from immunological or nonimmunological host responses, although the latter is more common. Nettles, such as *Urtica* spp., are examples of plants that cause nonimmunologic contact urticaria. These plants have hollow stinging hairs that inject a chemical after penetration of the skin. A burning sensation and pruritis occur almost immediately.

A number of cultivated plants of the carrot and rue families sensitize the skin to long-wave ultraviolet light. Within 6 to 24 hours of contact with the plant and exposure to sunlight or fluorescent light, the area of contact will selectively burn. In some cases, hyperpigmentation may persist for several months.

Some plants contain primary chemical irritants that produce skin damage resembling that from contact with a corrosive acid. The reaction depends on the potency of the irritant. The most serious reactions involve the eye. *Daphne* spp. and *Euphorbia* spp. are examples of plants containing chemical irritants.

For additional information on plants causing dermatitis, contact the Armed Forces Medical Intelligence Center, Fort Detrick, MD, (301) 619-7574, DSN: 343-7574; FAX: (301) 619-2409 (DSN = 343).

Table 2. Plants that Cause Contact Dermatitis in North Africa

Plant Species	Algeria	Egypt	Libya	Morocco	Tunisia
Abrus precatorius	+	+			
Aleurites spp.	+				
Bryonia spp.	+	+	+	+	
Croton spp.	+	+		+	+
Calotropis spp.			+		
Daphne spp.	+		+	+	
Datura spp.	+	+	+	+	+
Duranta erecta (*D. repens*)			+		
Euphorbia spp.	+	+	+	+	+
Gnidia spp. (*Lasiosiphon* spp.)		+			+
Jatropha spp.	+	+	+	+	+
Mucuna spp.			+		
Rhus spp. (*Toxicodendron* spp.)	+	+	+	+	+
Ricinus communis		+	+		
Spirostachys spp.			+		
Sterculia spp.			+		
Tamus spp.		+	+		
Urera spp.			+		

2. Systemic Toxicity from Ingestion of Plants.
Most wild plants contain toxic components, and military personnel must be instructed not to consume local plants unless necessary for survival. Wild plants are difficult to identify, and poisonous plants can easily be mistaken for plants with parts safe to eat. Military personnel will be forced by necessity to consume wild plants during survival operations. To avoid accidental poisoning, they should be thoroughly trained to recognize common edible plants in the region.

Many plants have fruiting bodies that appear edible or have attractive parts, such as the castor bean. Some military personnel may be tempted to consume plants because they are used locally for various purposes. Local lore may attribute medicinal qualities, psychotropic or aphrodisiac effects to native plants. Medical personnel and combat commanders must be aware that some troops will be tempted to experiment with native plants.

In most cases of poisoning, care is usually symptom driven. The age and medical condition of the patient influence toxic response and medical treatment. Special monitoring and specific drug therapy are indicated in some instances. Because life-threatening intoxications are rare, military medical personnel may have little experience in management of plant poisoning. It is inappropriate to assume that the toxicity exhibited by a single member of a genus will apply to all other species of that genus or that all toxic members of a genus will have similar effects. Most toxic plants, regardless of their ultimate effects, induce fluid loss through vomiting and diarrhea. This is important when military personnel are operating in hot, arid areas. Plant toxicity varies with the plant part, maturity, growing conditions, and genetic variation.

TG 196, Guide to Poisonous and Toxic Plants, provides information on toxic plants common in the US that also occur in other regions of the world. It includes a list of state and regional poison control centers. For additional information, contact the Armed Forces Medical Intelligence Center, Fort Detrick, MD, (301) 619-7574, DSN: 343-7574; FAX: (301) 619-2409 (DSN = 343).

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Appendix A.1. Distribution of Mosquitoes in North Africa. (+ = Present; ? = Uncertain)

Mosquito Species	Algeria	Canary Islands	Egypt	Libya	Morocco	Tunisia
Aedes aegypti					+	
Ae. albineus	+				+	
Ae. berlandi	+				+	
Ae. caspius	+	+	+	+	+	+
Ae. detritus			+		+	+
Ae. eatoni		+				
Ae. echinus	+				+	
Ae. geniculatus					+	
Ae. mariae	+			+	+	+
Ae. rusticus	+				+	
Ae. pulchritarsus					+	+
Ae. vittatus	+				+	+
Anopheles n. sp.			+			
An. algeriensis			+	+	+	
An. claviger	+				+	
An. tenebrosus			+	+	+	
An. dthali	+		+		+	+
An. cinereus hispaniola	+	+	+	+		+
An. hyrcanus				+		
An. labranchiae	+			+	+	+
An. marteri	+			+	+	+
An. multicolor	+	+	+	+	+	
An. pharoensis			+			
An. rhodesiensis rupicola			+			
An. rufipes broussesi	+			+		
An. sergentii		+	+	+	+	
An. sicaulti					+	
An. superpictus			+	+		
An. turkhudi			+		+	
An. ziemanni				+		
Culex adairi			+			
Cx. antennatus	+		+			+
Cx. arbieeni	+	+	+			
Cx. brumpti					+	

A.1. continued

Mosquito Species	Algeria	Canary Islands	Egypt	Libya	Morocco	Tunisia
Cx. deserticola	+		+		+	+
Cx. duttoni					+	
Cx. gamma	+					
Cx. hortensis		+			+	
Cx. impudicus					+	
Cx. laticinctus	+	+	+	+	+	
Cx. martinii					+	
Cx. mimeticus	+		+		+	+
Cx. modestus	+				+	
Cx. perexiguus	+		+	+	+	+
Cx. pipiens	+	+	+	+	+	+
Cx. poicilipes			+			
Cx. pusillus	+		+	+		+
Cx. simpsoni					+	
Cx. sinaiticus			+			
Cx. theileri	+	+	+	+	+	+
Cx. tritaeniorhynchus			+			
Culiseta longiareolata		+	+	+	+	
Cs. subochrea	+		+	+	+	+
Uranotaenia balfouri	+		+		+	+
Ur. unguiculata			+	+		

Appendix A.2. Distribution of Sand Flies in North Africa. (+ = Present; ? = Uncertain)

Species	Algeria	Canary Islands	Egypt	Libya	Morocco	Tunisia
Phlebotomus alexandria	+	+	+	+	+	+
P. ariasi	+				+	+
P. bergeroti	+		+	+	+	+
P. caucasicus			+			
P. chabaudi	+	+	+	+	+	+
P. chadlii	+					
P. fortunatarum		+			+	+
P. kazeruni	+					
P. langeroni	+		+	+	+	+
P. longicuspis	+	+	+	+	+	+
P. longiductus		+	+	+	+	+
P. major syriacus			+	+	+	+
P. mariae					+	
P. orientalis				+		
P. papatasi	+	+	+	+	+	+
P. perfiliewi	+				+	+
P. perniciosus	+	+		+	+	+
P. riouxi					+	+
P. saevus	+	+	+	+	+	+
P. sergenti	+	+	+	+	+	+
P. tobbi				+		
Sergentomyia adleri				+		
S. africanus					+	
S. antennata	+		+	+	+	+
S. bedfordi				+		
S. christophersi	+			+	+	+
S. cineta				+		
S. clydei	+			+	+	
S. dreyfussi	+			+	+	+
S. eremitis	+					
S. fallax	+	+		+	+	+
S. lewisi					+	
S. minuta parroti	+	+		+	+	+
S. palestinensis				+		
S. squamipleuris			+			
S. tiberiadis	+					

Appendix A.3. Distribution of Ticks in North Africa. (+ = Present; ? = Uncertain)

Tick Species	**Algeria**	**Canary Islands**	**Egypt**	**Libya**	**Morocco**	**Tunisia**
ARGASIDAE						
Argas arboreus			+			
A. brumpti			+			
A. boueti			+			
A. confusus			+			
A. persicus			+	+		+
A. reflexus hermanni	+		+		+	+
A. r. reflexus			+			
A. transgariepinus			+			
A. vespertilionis		+	+			
Ornithodoros arenicolous			+			
O. delanoei delanoei			+			
O. erraticus			+			
O. foleyi			+	+		
O. maritimus					+	
O. salahi			+			
O. savignyi			+	+		
O. tholozani tholozani			+	+		
IXODIDAE						
Boophilus annulatus	+		+	+	+	+
B. decoloratus				**?**		
B. microplus				**?**		
Dermacentor marginatus	+				+	
Haemaphysalis erinacei	+		+	+		+
H. l. leachi	**?**		+		**?**	
H. otophila				+		
H. punctata	+					+
H. sulcata			+			+
Hyalomma a. anatolicum			+	+	+	+
H. detritum	+		+		+	+
H. dromedarii	+		+	+	+	+
H. excavatum	+		+	+	+	+
H. franchinii			+	+		+
H. i. impeltatum	+		+	+		+
H. lusitanicum	+				+	

3. continued

Tick Species	Algeria	Canary Islands	Egypt	Libya	Morocco	Tunisia
H. m. marginatum	+		+		+	+
H. marginatum rufipes			+	+		
H. marginatum turanicum			+	+		
H. schulzei			+			
H. sinaii			+			
H. truncatum			+			
Ixodes kaiseri			+			
I. r. redikorzevi			+			
I. ricinus	+	+	+			+
Rhipicephalus bursa	+			+	+	+
R. camicasi			+			
R. guilhoni			+			
R. fulvus	+					+
R. s. sanguineus	+		+	+	+	+
R. turanicus	+		+		+	+

Appendix A.4. Distribution of Fleas in North Africa. (+ = Present; ? = Uncertain)

Flea Species	Algeria	Canary Islands	Egypt	Libya	Morocco	Tunisia
CERATOPHYLLIDAE						
Ceratophyllus columbae			+			
C. farreni						+
C. fringillae					+	
C. hirundinis						+
Myxopsylla laverani			+		+	+
Nosopsyllus atlantis					+	
N. barbarus	+	+			+	+
N. fasciatus			+	+	+	+
N. garamanticus						+
N. geneatus			+			
N. henleyi	+		+	+	+	+
N. maurus						+
N. londiniensis			+		+	+
N. oranus	+				+	
N. sinaiensis			+			
N. theodori			+			
COPTOPSYLLIDAE						
Coptopsylla africana						+
Coptopsylla wassiliewi	+			+	+	+
HYSTRICHOPSYLLIDAE						
Ctenophthalmus andorrensis					+	
C. russulae					+	+
Hystrichopsylla talpae					+	
Rhadinopsylla masculana	+		+		+	+
Stenoponia tripectinata complex	+	+	+	+	+	+
Typhloceras favosus					+	+
T. poppei	+				+	
ISCHNOPSYLLIDAE						
Araeopsylla gestroi	+		+			
A. wassifi			+			
Chiropteropsylla aegyptica			+			
C. brockmani			+			

A.4. continued

Flea Species	Algeria	Canary Islands	Egypt	Libya	Morocco	Tunisia
Ischnopsyllus consimilis			+			
I. hispanicus					+	
I. intermedius	+				+	
I. octactenus	+	+			+	+
Nycteridopsylla ancyluris	+					
N. pentactena	+					
Rhinolophopsylla unipectinata	+				+	+
LEPTOPSYLLIDAE						
Caenopsylla assimulata						+
C. janineae	+					
C. laptevi			+			
C. mira					+	+
Hopkinsipsylla occulta			+	+		+
Leptopsylla algira					+	
L. segnis		+	+		+	+
L. taschenbergi	+				+	
Mesopsylla tuschkan			+			
PULICIDAE						
Archaeopsylla erinacei	+				+	+
Ctenocephalides canis	+	+	+	+	+	+
C. felis		+	+	+	+	+
Echidnophaga gallinacea	+	+	+		+	+
E. murina		+	+		+	+
Pariodontis r. riggenbachi					+	+
Parapulex chephrenis			+			
Pulex irritans	+	+	+	+	+	+
Spilopsyllus cuniculi					+	
Synosternus c. cleopatrae	+		+	+	+	+
S. pallidus			+	+		+
Xenopsylla blanci	+				+	
X. brasiliensis		+				
X. cheopis	+	+	+	+	+	+
X. conformis mycerini	+		+			+
X. cunicularis					+	
X. dipodilli			+			

A.4. continued

Flea Species	Algeria	Canary Islands	Egypt	Libya	Morocco	Tunisia
X. gratiosa						+
X. guancha		+				
X. nubica	+		+	+	+	+
X. ramesis	+		+	+	+	+
X. taractes			+	+		+

Appendix A.5 Distribution of Scorpions in North Africa

Country	**Algeria**	**Canary Islands**	**Egypt**	**Lybia**	**Morocco**	**Tunisia**
BUTHIDAE						
Androctonus amoreuxi amoreuxi	+		+	+	+	+
A. a. hebraeus			+			
A. australis	+		+	+		+
A. bicolor bicolor			+			
A. b. aeneas	+					+
A. b. liouvillei	+				+	
A. crassicauda crassicauda			+			
A. c. gonneti					+	
A. hoggarensis	+					
A. mauretanicus mauretanicus					+	
A. m. bourdoni					+	
A. sergenti					+	
Anoplobuthus parvus					+	
Buthacus arenicola	+		+	+		+
B. foleyi	+			+		
B. leptochelys	+		+	+	+	
B. spatzi	+					+
Butheloides maroccanus					+	
Buthiscus bicalcaratus	+					+
Buthus atlantis					+	
B. atlantis atlantis					+	
B. a. parroti					+	
B. moroccanus					+	
B. occitanus barcaeus				+		
B. o. israelis			+			
B. o. mardochei					+	
B. o. malhommei					+	
B. o. occitanus					+	
B. o. paris	+				+	+
B. o. tunetanus	+		+		+	+
Hottentotta franzwerneri franzwerneri	+				+	
H. f. gentili	+				+	
H. scaber			+			
Centruroides gracilis		+				
Cicileus exilis	+					
Compsobuthus wernei klaptoczi				+		
C. w. longipalpis			+			
C. w. werneri			+	+		

Leiurus quinquestriatus quinquestriatus	+		+	+		
L. q. hebraeus			+			
Lissothus bernardi	+					
Orthochirus aristidis			+			
O. innesi	+		+	+		+
O. scrobiculosus negebensis			+			
EUSCORPIIDAE						
Euscorpius carpathicus						+
E. flavicaudis	+					+
E. italicus					+	
DIPLOCENTRIDAE						
Nebo hierichontus			+			
SCORPIONIDAE						
Scorpio maurus fuliginous					+	
S. m. hesperus					+	
S. m. maurus	+					+
S. m. mogadorensis					+	
S. m. palmatus			+			
S. m. subtypicus					+	
S. m. tunetanus	+				+	+
S. m. weidholzi					+	

Appendix B.1. Vector Ecology Profiles of Malaria Vectors in North Africa.

Species	Larval Habitats	Feeding Behavior	Resting Behavior	Flight Behavior
An. claviger	Wells and cisterns.	Bites man and other animals, indoors and outdoors.	Rests indoors after feeding.	Short-range flier, specific range unknown.
An. hispaniola	Found in shallow pools in oases.	Bites man and animals. Outdoor feeder.	Rests outdoors.	Presumed to be a short-range flier. Flight range unknown.
An. labranchiae	Develops in fresh or brackish marshes, swamps or irrigated fields; tolerates warm water habitats, particularly in coastal areas.	Feeds on man and domestic animals.	Rests indoors or outdoors after feeding.	No flight range information available.
An. multicolor	Lives in shallow ponds and pools near cultivated fields. Lives in polluted (without sewage) urban ground pools, slow-moving streams or saline seepages.	Feeds on man and domestic animals, preferring man only in the absence of animals.	Feeds and rests indoors and outdoors, often preferring indoors or animal pens.	No flight range information available.
An. pharoensis	Marshes, swamps and rice fields. Favors emergent vegetation.	Bites man and domestic animals, indoors and outdoors.	Rests outdoors after feeding.	Strong flier, 10 km or more.
An. sergentii	Springs, date palm and rice irrigation plots.	Bites man and other animals, indoors and outdoors.	Rests in human dwellings or caves.	Moderate flight range, may exceed 5 km.
An. superpictus	Clear, sunlit water, usually without vegetation.	Bites man and other animals both indoors and outdoors.	Rests in human dwellings, animal shelters and caves.	Short to medium range flier, rarely flies more than 5 km from larval habitat.

Appendix B.2. Vector Ecology Profiles of Tick Vectors in North Africa.

Species	Geographic Distribution	Potential Hosts	Disease Transmission	Bionomics/Habitat Information
Boophilus annulatus	Algeria, Egypt, Libya, Morocco and Tunisia.	Adults and immatures feed on cattle, sheep, rarely horses and humans.	A minor CCHF vector.	A 1-host tick. All stages of the life cycle are generally spent on cattle. After feeding and mating, females rest up to a month before laying eggs. Life cycle <1 year.
Ornithodoros erraticus	Algeria, Egypt, Libya, Morocco and Tunisia, especially coastal areas.	Adults: camels, swine, dogs, donkeys and, sometimes, humans. Immatures: gerbils and other rodents.	Vectors tick-borne relapsing fever.	Multi-host soft tick. Feeds quickly in 1-2 hours, usually at night. Usually has 3-4 immature instars. Females mate and may live several years without a bloodmeal. Often lives in rodent burrows.
O. savignyi	The northern Sinai of Egypt.	Adults: camels, goats and, rarely, humans.	Vectors tick-borne relapsing fever.	Multi-host soft tick. Found along trails or under trees. Rest of bionomics similar to *O. erraticus*.
O. tholozani	Libya.	Adults: camels, sheep and, rarely, humans. Immatures: unknown.	Vectors tick-borne relapsing fever.	Multi-host soft tick. Found in caves, huts, cabins, or stables. Rest of bionomics similar to *O. erraticus*.

B.2. Continued.

Species	Geographic Distribution	Potential Hosts	Disease Transmission	Bionomics/Habitat Information
Dermacentor marginatus	Algeria.	Adults: sheep, cattle, dogs, deer and humans. Immatures: rodents, hares, foxes and shrews.	Potential vector of CCHF.	A 3-host tick. Inhabits a wide range of biotopes including brush, forests, and steppes. Resists desiccation. May diapause on its host. Lays up to 6,200 eggs.
Haemaphysalis concinna	Algeria and Morocco.	Adults: deer and livestock, especially cattle. Immatures: hedgehogs, rabbits, or birds.	Boutonneuse fever.	A 3-host tick. Occurs in moist, mountainous biotopes of the coastal Atlas Mountains. Engorgement is slow, taking up to 20 days for females.
H. dromedarii	Algeria, Egypt, Libya, Morocco and Tunisia.	Adults: camels, goats and dogs. Immatures: rodents, gerbils, hares, birds.	A zoonotic vector of CCHF. Transovarial transmission occurs.	A 2- or 3-host tick, depending on host. Immatures feed on a wide range of small mammals and sometimes lizards. Bionomics similar to other *Hyalomma* species.
H. impeltatum	Algeria, Egypt, Libya and Tunisia.	Adults: camels, cattle, sheep and dogs. Immatures: gerbils, and other rodents, hares, birds.	A zoonotic vector of CCHF. Transovarial transmission occurs.	A 2-host tick. Immatures feed on small animals. Inhabits semi-desert, savanna, and steppe biotopes.

B.2. Continued.

Species	Geographic Distribution	Potential Hosts	Disease Transmission	Bionomics/Habitat Information
H. rufipes	Egypt and Libya.	Adults: camels, dogs, cattle and sometimes, humans. Immatures: gerbils and other rodents, hares, birds.	Good vector of CCHF. Transovarial transmission occurs regularly. Transmits boutonneuse fever.	A 2-host tick. Females oviposit after dropping from the host and die soon afterwards. Females feed for 6-12 days. Species resists drought, cold, and heat. Distributed by migrating birds and along caravan routes.
H. marginatum turanicum	Egypt and Libya.	Adults: cattle, camels, sheep and, rarely, humans. Immatures: gerbils and other rodents, hares, birds.	Good vector of CCHF. Transovarial transmission occurs.	A 2-host tick. Bionomics similar to *H. rufipes*.
Hyalomma anatolicum anatolicum	Algeria, Egypt, Libya, Morocco and Tunisia.	Adults: camels, sheep, goats, cattle, dogs and sometimes, humans. Immatures: gerbils and other rodents, hares, birds.	Good vector of CCHF. Transovarial transmission occurs.	A 3-host tick. Dispersed widely from steppes and deserts, often along caravan and cattle routes. Ticks often harbor in feedlots. Nymphs feed on host's ears. Commonly active in winter months. Aggressive host-seeker. Resistant to temperature and humidity extremes.
H. a. excavatum	Algeria, Egypt, Morocco, Tunisia and probably Libya.	Adults: cattle, camels and, sometimes, humans. Immatures: gerbils and other rodents, hares, birds.	Good vector of CCHF. Transovarial transmission occurs.	A 3-host tick. Immatures parasitize small mammals. Species remains active in winter in warmer regions. Resistant to temperature extremes and aridity.

B.2. Continued.

Species	Geographic Distribution	Potential Hosts	Disease Transmission	Bionomics/Habitat Information
Ixodes ricinus	Algeria, Tunisia, and the Canary Islands.	Adults: sheep, cattle, deer, foxes and humans. Immatures: rodents, hares, hedgehogs, foxes, dogs and humans.	Principal vector of Lyme disease. Rarely vectors CCHF.	A 3-host tick. Ranges widely in moist, dense, forest biotopes. Poorly adapted to desiccation. Life cycle requires 2-4 years. Females lay up to 2,300 eggs.
Rhipicephalus bursa	Algeria, Libya, Morocco and Tunisia.	Adults: swine, cattle, sheep, rarely horses. Immatures: rodents, hares, foxes and shrews.	An occasional zoonotic CCHF vector.	A 2-host tick. Has a 1-year life cycle. Adults overwinter. May become inactive if a host is not found in the summer.
R. sanguineus	Throughout North Africa.	Adults: dogs, cattle, horses, sheep, sometimes humans. Immatures: rodents, hares, foxes and shrews.	An occasional CCHF vector. Also transmits boutonneuse fever.	A 3-host tick. Adults feed in ears or between toes of dogs. Immatures prefer long hair at the back of the neck. Females crawl upward and lay eggs in cracks of walls or ceilings.

Appendix C
Pesticide Resistance in North Africa.

Vector-borne diseases are an increasing cause of death and suffering in many areas of the world. Efforts to control these diseases have been founded on the use of chemical pesticides. However, the spread of resistance among arthropods has rendered many pesticides ineffective, while few substitute pesticides are being developed.

Resistance is formally defined by the WHO as "the development of an ability in a strain of some organism to tolerate doses of a toxicant that would prove fatal to a majority of individuals in a normal population of the same species." Resistance has a genetic basis and is the result of a change in the genetic composition of a population as a direct result of the selection effects of the pesticide.

Early detection and monitoring are vital to resistance management. Historically, standardized methods, test kits and insecticides were provided by WHO. The simplest method of detecting resistance is the diagnostic dose test. The diagnostic dose is a predetermined insecticide dose known to be lethal to a high proportion of susceptible individuals, but that a high proportion of resistant individuals can tolerate. A list of recommended diagnostic doses of many insecticides for a number of arthropod vectors is available from WHO. For terrestrial and/or adult stages, the insecticide is either applied topically or insects are exposed to a surface treated with insecticide. For aquatic stages, insecticide is added to water at given concentrations.

New approaches use rapid biochemical tests to detect resistance and determine resistance mechanisms. These methods permit rapid multiple assays of a single specimen. Worldwide application of biochemical assays will require production of standardized kits similar to the insecticide bioassay kits supplied by WHO. The choice of method to test for resistance is of great importance in order to determine resistance mechanisms. Consult TG 189, Procedures for the Diagnostic Dose Resistance Test Kits for Mosquitoes, Body Lice, and Beetle Pests of Stored Products. To obtain test kits and additional recommendations for resistance testing contact:

USACHPPM/Entomological Sciences Program
5158 Blackhawk Road
Aberdeen Proving Ground, MD 21010-5422
Tel: (410) 436-3613
DSN 584-3613, FAX (410) 436-2037

Pesticide resistance can be classified into two broad categories: physiological and behavioral. There are many mechanisms of physiological resistance, including reduced penetration of insecticides through the cuticle, presence of enzymes that detoxify the insecticide, and reduced sensitivity of the target site of the insecticide. Physiological resistance can confer cross-resistance to structurally related insecticides of the same chemical class or related classes. Some vector populations have acquired several resistance mechanisms providing multiple resistance to a variety of insecticide classes.

Many vector control programs have reached a stage where resistance is so great that few chemical alternatives are available.

In recent years, synthetic pyrethroids have replaced widely used classes of insecticides such as organophosphates, carbamates, and chlorinated hydrocarbons. These pyrethroids have shown great promise for vector control due to their low mammalian toxicity and ability to quickly immobilize and kill arthropods at low dosages. Unfortunately, resistance has been detected in several medically important arthropods. An issue of concern in vector control is whether DDT resistance confers cross-resistance to pyrethroids as a result of similar resistance mechanisms. Increasing pyrethroid resistance is of particular concern to the US military because of the widespread use of permethrin and other pyrethroids in BDUs, bednets, and vector control programs.

Changes in behavior that result in reduced contact with an insecticide include a reduced tendency to enter treated areas or an increased tendency to move away from a surface treated with insecticide once contact is made. These are population-based changes in a species' genetics resulting from the selection pressure of insecticide use. Avoidance behavior is widespread but poorly understood. Some form of behavioral avoidance has been documented for virtually every major vector species. Methods to detect and determine behavioral resistance have not been standardized and are difficult to interpret.

Pesticide resistance will be an increasing problem for vector control personnel. More than 90% of all pesticides are used for agricultural purposes. Insecticide resistance in at least 17 species of mosquitoes in various countries has occurred because of indirect selection pressure by agricultural pesticides. The development of organophosphate and carbamate resistance in *Anopheles sacharovi*, *An. hyrcanus* and *An. maculipennis* in the Chukurova plain and the northern area around Osmanjik in Turkey has been attributed to the use of chemicals for agricultural pest control.

A pesticide use strategy that will prevent the evolution of resistance has not been developed. Tactics to manage or delay the development of resistance include: 1) using nonchemical methods of control as much as possible, 2) varying the dose or frequency of pesticide application, 3) using local rather than area-wide application, 4) applying treatments locally only during outbreaks of vector-borne diseases, 5) using less persistent pesticides, 6) treating only certain life stages of the vector, 7) using mixtures of pesticides with different modes of action, 8) using improved pesticide formulations, 9) rotating pesticides having different modes of action, and 10) using synergists.

Reports of resistance must be interpreted carefully. Resistant populations tend to revert to susceptible status once insecticide selection pressure has been removed. Isolated reports of resistance, although recent, may indicate local resistance that has not become widespread. The length of time an insecticide has been used at a location may not be helpful in predicting the presence of resistance. Vectors in some countries have never developed resistance to DDT, despite decades of use in malaria control. Only appropriate resistance monitoring can guide the vector control specialist in the selection of a suitable insecticide.

Appendix C.1. Specific Reports of Pesticide Resistance in North Africa.

Country	Species/Stage	Insecticide	Location	Date of Test
Egypt	*Culex pipiens* adults	DDT	Mansoura Province	1979
Egypt	*Argas persicus* nymphs, adults	trichlorfon	Province of Fars	1982
Egypt	*Musca domestica* adults	lindane	Fayoum Governorate	1982
Egypt	*M. domestica* adults	fenthion	Alexandria	
Tunisia	*Cx. pipiens* adults	temephos, DDT, chlorpyrifos, propoxur, permethrin	17 locations throughout Tunisia	1990-1996
Tunisia	*Cx. pipiens* larvae	temephos	Sayada	1990
Tunisia	*Cx. pipiens* larvae	chlorpyifos, temephos, fenthion	Tunis	1984- 1988
Tunisia	*Cx. pipiens* larvae	chlorpyrifos, permethrin, temephos	Sfax	1984-1988
Tunisia	*Aedes detritus*	chlorpyrifos, temephos	Tunis	1984

Appendix C.2.
Published Reports of Insecticide Resistance Testing in North Africa.*

WHO. 1986. Resistance of vectors and reservoirs of disease to pesticides. Tenth report of the WHO expert committee on vector biology and control. WHO Tech. Rep. Ser. 737: 87 pp.

Egypt

Aboul, Ela R.G., T.A. Morsy, B.M.R. El Gozamy, D.A. Ragheb and B.M.R. El Gozamy. 1993. The susceptibility of the Egyptian *Phlebotomus papatasi* to five insecticides. J. Egypt. Soc. Parasitol. 23: 69-84.

Curtis, C.F. and N. Pasteur. 1981. Organophosphate resistance in vector populations of the complex of *Culex pipiens* L. (Diptera: Culicidae). Bull. Entomol. Res. 71: 153 - 161.

El Kady, G.A. 1993. Susceptibility of three tick *Hyalomma* spp. from North Sinai Governorate to certain pesticide groups. J. Egypt. Soc. Parasitol. 23: 785 -794.

El Kammah, K. M., S.O. El Beshlawy and L.I. Oyoun. 1982. Effects of certain acaricides on the mortality rates of *Argas* (*Persicargas*) *persicus* (Ixodoidea: Argasidae). J. Egypt. Soc. Parasitol. 12: 459-466.

Fahmy, A.R., E.I.M. Khater, B. El Sawaf and M. Shehata. 1996. Insecticide susceptibility status of field populations of the sandfly *Phlebotomus papatasi* in the Sinai Peninsula, Egypt. WHO – LEISH 38: 9 pp.

Guneidy, A., A. Ebeid and H. Salem. 1988. Measurements of the resistance in adult *Culex pipiens* in Egypt. Indian J. Entomol. 50: 82 -99.

Guneidy, A, A. Ebeid and H. Salem. 1988. Development and reversion of malathion resistance in adult *Culex pipiens*. Indian J. Entomol. 50: 45-54.

Morsy, T.A., R.G. Ela Aboul, B.M.R. El Gozamy, M.M.M. Salama and D.A. Ragheb. 1993. Residual effects of four insecticides applied for indoor control of *Phlebotomus papatasi* (Scopoli). J. Egypt. Soc. Parasitol. 23: 485-492.

Mosallam, S.S. 1987. Study on house fly populations and susceptibility to some insecticides in Fayoum Governorate, Egypt. J. Egypt. Soc. Parasitol. 17: 115 -122.

Mosallam, S.S. 1986. The house fly population and susceptibility to insecticides in Alexandria. J. Egypt. Soc. Parasitol. 16: 733-738.

Shoukry, A., M.S. Hamed, M.A. Said, A.M. Gad, M.A. Kenawy and S. El Said. 1990. The mode of inheritance of fenitrothion resistance in *Culex pipiens* L. larvae (Diptera: Culicidae). J. Egypt. Soc. Parasitol. 20: 683-689.

Soliman, A.A. 1979. Entomological (biological – toxicological – ecological) and epidemiological investigations in relation to mosquito vectors of Rift Valley fever in Egypt with the aim of developing control strategies. Status Prog. Rep. ONR Res. Grant No. N0014-79-G-0069. 78 pp.

Taylor, R.N. 1982. Insecticide resistance in house flies from the Middle East and North Africa with notes on the use of various bioassay techniques. Pesticide Sci. 13: 415 - 425.

Villani, F., G.B. White, C.F. Curtis and S.J. Miles. 1983. Inheritance and activity of some esterases associated with organophosphate resistance in mosquitoes of the complex of *Culex pipiens* L. (Diptera; Culicidae). Bull. Entomol. Res. 73: 153 -170.

Tunisia

Cheikh, H.B., Z. Ben Ali Haouas, M. Marquine and N. Pasteur. 1998. Resistance to organophosphorus and pyrethroid insecticides in *Culex pipiens* (Diptera: Culicidae) from Tunisia. J. Med. Entomol. 35: 251 -260.

Cheikh, H.B., M. Marrakchi and N. Pasteur. 1995. [Detection of a very high resistance to chlorpyrifos and permethrin in populations of *Culex pipiens* in Tunisia.] Arch. Inst. Pasteur Tunis 72: 7-12.

Cheikh, H.B. and N. Pasteur. 1993. Resistance to temephos, an organophosphate insecticide in *Culex pipiens* from Tunisia, North Africa. J. Am. Mosq. Control Assoc. 9: 335-337.

Kooli, J., W. Daoud and A. Scirocchi. 1990. Evaluation of the levels of susceptibility to chlorpyrifos and temephos in several strains of *Culex pipiens* and *Aedes detritus* from the Tunis region. Rev. Parassitol. 5: 174-177.

Kooli, J. and A. Rhaiem. 1989. [Sensitivity of mosquito larvae to insecticides in the region of Tunis in 1984 and 1988.] Arch. Inst. Pasteur Tunis 66: 61 -71.

* Only papers published in the 20 years prior to preparation of this document are included.

Appendix D
Sources of Snake Antivenoms

1	Perusahaam Negara Biofarms 9, Jalan Pasteur Bandung, Indonesia
2	Behring Institut, Behringwerke AG, D3550 Marburg (Lahn), Postfach 167, Germany. Telephone: (06421) 39-0. Telefax: (06421) 660064. Telex: 482320-02 bwd.
3	Institute of Epidemiology and Microbiology, Sofia, Bulgaria
4	Shanghai Vaccine and Serum Institute, 1262 Yang An Road (W), Shanghai, PRC
5	Commonwealth Serum Laboratories, 45 Poplar Road, Parkville, Victoria 3052, Australia Telegram: "SERUMS," Melbourne Telex: AA32789, Telephone: 387-1066
6	Foreign Trade Company, Ltd., Kodandaka, 46 Prague 10, Czech Republic
7	Fitzsimmons Snake Park, Box 1, Snell Park, Durban, South Africa
8	Haffkine Bio-pharmiceutical Corporation, Ltd., Parel, Bombay, India
9	Chiba Serum Institute, 2-6-1 Konodai, Ichikawa, Chiba Prefecture, Japan
10	Institut d'État des Serums et Vaccins Razi, P.O. Box 656, Tehran, Iran
11	Central Research Institute, Kasauli (Simia Hills), (H.P.) India
12	Kitasato Institute, 5-9-1 Shirokane, Minato-ku, Tokyo, Japan
13	The Chemo-Sero Therapeutic Research Institute, Kumamoto, 860 Kyushu, Japan
14	National Institute of Health, Biological Production Division, Islamabad, Pakistan. Telex: 5811-NAIB-PK, Telephone: 820797, 827761
15	Research Institute For Microbial Diseases, Osaka University, 3-1 Yamadoaka, Suite 565, Osaka, Japan, Telephone: (06) 877-5121
16	Institut Pasteur Production, 3 Boulevard Raymond Poincaré, 92430-Mames la Coquette, France. Telephone: (1) 47.41.79.22, Telex: PASTVAC206464F
17	Institut Pasteur d'Algérie Docteur Laveran, Algiers, Algeria
18	Industrial and Pharmaceutical Corporation, Rangoon, Burma
19	Rogoff Medical Research Institute, Beillinson Medical Center, Tel-Aviv, Israel
20	South African Institute for Medical Research, P.O. Box 1036, Johannesburg 2000, Republic of South Africa. Telegraph: "BACTERIA", Telephone: 724-1781
21	Instituto Sieroterapica e Vaccinogeno Toscano "Sclavo", Via Fiorentina 1, 53100 Siena, Italy.
22	National Institute of Preventive Medicine, 161 Kun-Yang St., Nan-Kang, Taipei, Taiwan
23	Takeda Chemical Industries, Ltd., Osaka, Japan
24	Research Institute of Vaccine and Serum, Ministry of Public Health U.I. Kafanova, 93 Tashkent, USSR
25	Red Cross Society, Queen Saovabha Memorial Institute, Rama 4 Road, Bangkok, Thailand
26	Twyford Pharmaceutical Services Deutschland, GmbH, Postfach 2108 05, D-6700 Ludwigshafen am Rhein, Germany
27	Institute of Immunology, Rockefellerova 2, Zagreb, Yugoslavia

Appendix E
Selected List of Taxonomic Papers and Identification Keys

(Papers marked with an asterisk include a taxonomic key for identification of species.)

Centipedes and Milipedes

Schubart, O. 1963. [On the Diplopoda of Algeria.] Bull. Soc. Sci. Natur. Phys. Maroc 43: 79-94.

Ceratopogonidae

Braverman, Y., N. Messaddeq, C. Lemble and M. Kremer. 1996. Reevaluation of the taxonomic status of the *Culicoides* spp. (Diptera: Ceratopogonidae) from Israel and the eastern Mediterranean and review of their potential medical and veterinary importance. J. Am. Mosq. Control Assoc. 12: 437-445.

Szadziewski, R. 1984. Ceratopogonidae (Diptera) from Algeria. VI. *Culicoides* Latr. Pol. Pismo Entomol. 54: 163-182.

Clastrier, J. 1975. Descriptions of some males of *Holoconops* (Diptera: Ceratopogonidae). Ann. Soc. Entomol. France 11: 587-607.*

Clastrier, J. 1972/73. [The genus *Leptoconops*, subgenus *Holoconops*, in North Africa.] Arch. Inst. Pasteur Algérie. 50/51: 23-52.*

Kremer, M., M. Hommel and H. Bailly-Choumara. 1971. [Third contribution to the faunistic study of the Culicoides of Morocco.] Ann. Parasitol. Hum. Comp. 46: 661 - 670.

Callot, J., M. Kremer and H. Bailly-Choumara. 1970. Description of *Culicoides coluzznii* n. sp. (Diptera: Ceratopogonidae). Bull. Soc. Zool. France 95: 709-718.

Cimicidae

Usinger, R.L. 1960. The Cimicidae of Egypt (Hemiptera). J. Egypt. Public Health Assoc. 35: 81-89.*

Culicidae

Glick, J.I. 1992. Illustrated key to the female *Anopheles* of southwestern Asia and Egypt (Diptera: Culicidae). Mosq. Syst. 24: 125-153.*

Ward, R.A. 1992. Third Supplement to "A catalog of the mosquitoes of the world (Diptera: Culicidae)." Mosq. Syst. 24: 177-230.

Farid, H.A., A.M. Gad, A.M. Salem and A.H. Kashef. 1991. Biochemical key to eight species of adult Egyptian mosquitoes. Med. Vet. Entomol. 5: 183 -191.*

Harbach, R.E. 1988. The mosquitoes of the subgenus *Culex* in southwestern Asia and Egypt (Diptera: Culicidae). Contr. Am. Entomol. Inst. 24: 1-240.*

Harbach, R.E., B.A. Harrison, A.M. Gad, M.A. Kenawy and S. El Said. 1988. Records and notes on mosquitoes (Diptera: Culicidae) collected in Egypt. Mosq. Syst. 20: 317-342.

Baez, M. 1987. [Preliminary atlas of the Canary Islands (Diptera, Cu licidae).] Vieraea 17: 193-202.

Harbach, R.E. 1985. Pictorial keys to the genera of mosquitoes, subgenera of *Culex* and the species of *Culex* (*Culex)* occurring in southwestern Asia and Egypt, with a note on the subgeneric placement of *Culex deserticola* (Diptera: Culicidae). Mosq. Syst. 17: 83-107.*

Gaffigan, T.V. and R.A. Ward. 1985. Index to the second supplement to "A catalog of the mosquitoes of the world (Diptera: Culicidae)." Mosq. Syst. 17: 52 -63.

Ward, R.A. 1984. Second supplement to "A catalog of the mosquitoes of the world (Diptera: Culicidae)." Mosq. Syst. 16: 227 -270.

Moussiegt, O. 1983. [The mosquitoes of Tunisia, their distribution. A. bibliography. 1983.] Entente Indépartementale pour la Démoustication du Littor al Méditerranéen 47: 29 pp.

Baez, M. and M. Fernandez. 1980. Notes on the mosquito fauna of the Canary Islands (Diptera: Culicidae). Mosq. Syst. 12: 349-355.

Knight, K.L. 1978. Supplement to "A catalog of the mosquitoes of the world (Diptera: Culicidae)." Thomas Say Foundation, Entomological Society of America, Vol. 6, 107 pp.

Knight, K.L. and A. Stone. 1977. A catalog of the mosquitoes of the world (Diptera: Culicidae). 2nd ed. Thomas Say Foundation, Entomological Society of Am erica, Vol. 6, 611 pp.

Senevet, G. et al. 1962. [On the subject of some species of *Myzomyia* of the Mediterranean basin and adjacent regions.] Arch. Inst. Pasteur Algérie 40: 126 -148.*

Abel-Malek, A. 1956. Mosquitoes of northeastern Sinai (Dipte ra: Culicidae). Bull. Soc. Entomol. Égypte 40: 97-107.*

Gaud, J. 1953. [Biographical notes on the Culicidae of Morocco.] Arch. Inst. Pasteur Maroc 4: 444-490.*

Callot, J. 1938. [Contribution to the study of mosquitoes of Tunisia and, especia lly, those of the southern part of the regency.] Arch. Inst. Pasteur Algérie 40: 126 -148.*

Diptera

Rognes, K. 1987. The taxonomy of the *Pollenia rudis* species group in the Holarctic region (Diptera: Calliphoridae). Syst. Entomol. 12: 475 -502.*

Shaumar, N.F., S.K. Mohamed and I.F.I. Shoukry. 1985. Flies of subfamily Muscinae (Diptera: Muscidae) in Egypt. J. Egypt. Soc. Parasitol. 15: 513 -523.

Steyskal, G.C et al. 1967. A list of Egyptian Diptera with a bibliography and key to families. Tech. Bull. Minist. Agric. U.A.R. 87 pp.*

Mammalia

Wilson, D.E. and D.M. Reeder. 1993. Mammal species of the world: a taxonomic and geographic reference. 2nd ed., Smithsonian Institution Press, Washington, DC, 1,206 pp.

Vesmanis, I.E. 1985. Small mammals from Algeria. Zool. Abh. Mus. Tierk. Dresden 40: 125-152.

Happold, D.C.D. 1984. Small Mammals. *In*: Key Environments. Sahara Desert. J.L. Cloudsley-Thompson ed. Pergamon Press Inc., New York.

Lay, D.M. 1983. Taxonomy of the genus *Gerbillus* (Rodentia: Gerbillinae) with comments on the application of generic and subgeneric names and an annotated list of species. Z. Saugetierkd. 48: 329-354.

Bernard, J. 1970. [Key to identify the rodents of Tunisia.] Arch. Inst. Pasteur Tunis 47: 265-307.*

Ranck, G.L. 1968. The rodents of Libya: taxonomy, ecology and zoogeographical relationships. U. S. Nat. Mus., Washington DC, Final Rpt. 283 pp.

Hoogstraal, H. 1962. A brief review of the contemporary land mammals of Egypt (including Sinai). 1. Insectivora and Chiroptera. J. Egypt. Pub. Hlth. Assoc. 37: 143 - 162.*

Setzer, H.W. 1958. I. The mustelids of Egypt. II. The gerbils of Egypt. J. Egypt. Publ. Hlth. Assoc. 33: 205-227.*

Wassif, K. 1956. Studies on gerbils of the subgenus *Dipodillus* recorded from Egypt. Ain. Shams. Sci. Bull. No. 1: 173-194.

Psychodidae

Seyedi-Rashti, M.A., A. Nadim, M.A. Rashti and M.A. Sayedi. 1992. The genus *Phlebotomus* (Diptera: Psychodidae : Phlebotominae) of the countries of the Eastern Mediterranean Region. Iranian J. Pub. Hlth. 21: 11-50.*

Belazzoug, S. 1991. The Sandflies of Algeria. Parassitologia 33 (Suppl. 1): 85 -87.

Morsy, T.A., A.G. El Missiry, A.M. Kamel, M.E. Fayad and I.M.A. El Sharkawy. 1990. Distribution of *Phlebotomus* species in the Nile Delta, Egypt. J. Egypt. Soc. Parasitol. 20: 589-597.*

Lane, R.P. and B. Alexander. 1988. Sandflies (Diptera: Phlebotominae) of the Canary Islands. J. Nat. Hist. 22: 313-319.

Martinez, O.E., E.G. Conesa, S.F. Diaz, O.E. Martinez, G.E. Consesa and S.F . Diaz. 1988. [Contributions to the knowledge of the phlebotomines (Diptera, Psychodidae) of the Canary Islands.] Rev. Iberica Parasitol. 48: 89-93.

El Sawaf, B.M., A. Shoukry, S. El Said, R.P. Lane, M.A. Kenawy, J.C. Beier and S. Abdel-Sattar. 1987. [Sandfly species composition along an altitudinal transect in southern Sinai, Egypt.] Ann. Parasitol. Hum. Comp., Paris 62: 467-473.

Dedet, J.P., K. Addadi and S. Belazzoug. 1984. [Phlebotomine sandflies (Diptera: Psychodidae) from Algeria.] Cashiers ORSTOM Ser. Entomol. Med. Parasitol 22: 99-128.*

Lewis, D.J. 1982. A taxonomic review of the genus *Phlebotomus* (Diptera: Psychodidae). Bull. Br. Mus. Nat. Hist. Entomol. London 45: 121-209.*

Belazzoug, S. and D. Mahzoul. 1980. [Note on the phleboto mine sandflies (Diptera, Psychodidae) of the Tassili N'Ajjer.] Arch. Inst. Pasteur Algerie, Algiers 55: 103 - 106.

Croset, H., J.A. Rioux, M. Maistre and N. Bayar. 1978. [The phlebotomines of Tunisia (Diptera, Phlebotominae). A revision of the systematic s, distribution and behavior.] Ann. Parasitol. (Paris) 53: 711-749.*

Rioux J.A., J. Perieres, R. Killick-Kendrick and M. Maistre. 1978. [Confirmation of the presence of *Sergentomyia antennata* in Tunisia.] Ann. Parasitol. Hum. Comp. 53:431-435.

Dedet, J.P. and K. Addadi. 1977. [Epidemiology of leishmaniasis in Algeria. 4. The phlebotomines (Diptera, Psychodidae) of the Aures region.] Arch. Inst. Pasteur Algerie, Algiers 52: 85-94.

Bailly-Choumara, H., E. Abonnenc and J. Pastre. 1971. [Contribut ion to the study of the phlebotomines of Morocco (Diptera, Psychodidae) with faunal and ecological results.] Cah. ORSTOM Entomol. Med. Parasitol. 9: 431-460.*

Croset, H., E.Abonnenc and J.A. Rioux. 1970. *Phlebotomus* (*Paraphlebotomus*) *chabaudi* n. sp. (Diptera: Psychodidae). Ann. Parasitol. Hum. Comp. 45: 863-873.

Reptiles

Harding K.A. and K.R.G. Welch. 1980. Venomous snakes of the world: a checklist. Pergamon Press, Oxford. 188 pp.

Marx, H. 1968. Checklist of the reptiles and amphibians of Egyp t. U.S. Naval Med. Res. Unit 3, Cairo, Spec. Publ. 91 pp.

1966. Poisonous snakes of the world, a manual for use by U.S. amphibious forces. NAVMED P-5099, BUMED, Department of the Navy, U.S. Gov. Print. Off., 212 pp.*

Marx, H. 1956. Keys to the liz ards and snakes of Egypt. 1956. U.S. Naval Med. Res. Unit 3, Cairo, Res. Rep. No. 005 050.39 45: 8 pp.*

Scorpions

Dupre, G. 1995. [The scorpions of Morocco. Description of a biotope: the Djbel Touchka.] Arachnides 25: 1-4.

El Hennawy, H.K. and H.K. El Hennawy. 1992. A catalogue of the scorpions described from the Arab countries (1758-1990). Serket 2: 95-153.*

El Hennawy, H.K. and H.K. El Hennawy. 1990. Key to scorpion families (Arachnida: Scorpionida). Serket 2: 14-19.*

El Hennawy, H.K. 1987. A simplified key to Egyptian scorpion species (Arachnida: Scorpionida) Serket 1: 15-17.*

Vachon, M. and R. Kinzelbach. 1987. On the taxonomy and distribution of the scorpions of the Middle East. *In*: Proceedings of the symposium on the fauna and zoogeography of the Middle East, Mainz, 1985. By F. Krupp, W. Schneider and R. Kinzelbach, [eds.] Naturwissenschaften 28: 91-103.

Levy, G. and P. Amitai. 1980. Fauna Palaestina: Arachnida I: Scorpiones. Isr. Acad. Sci. Human. 132pp.

Le Corroller, Y. 1967. [Scorpions in Morocco.] Arch. Inst. Pasteur Algérie 45: 62-71.*

Vachon, M. 1966. [List of scorpions found in Egypt, Arabia, Israel, Libya, Syria, Jordan, Turkey, Iraq, and Iran.] Toxicon 4: 209-218.

Vachon, M. 1952. [Studies on scorpions.] Insitut Pasteur d'Algérie. Algiers, Algeria. 481 pp.

Simuliidae

Crosskey, R.W. 1988. Taxonomy and geography of the blackflies of the Canary Islands (Diptera: Simuliidae). J. Nat. Hist. 22: 321-355.*

Gagneur, J. and M. Clergue-Gazeau. 1988. Simuliidae of Algeria (Diptera: Nematocera). I. Biogeographical and ecological data on the species of west Algeria. Ann. Limnol. 24: 275-284.

Crosskey, R.W. and R.W. Ashford. 1981. The occurrence of *Simulium* s.l. in the Libyan Arab Republic. Ann. Trop. Med. Parasitol. 75: 647-651.

Siphonaptera

Adams, N.E. and R.E. Lewis. 1985. An annotated catalogue of primary types of Siphonaptera in the National Museum of Natural History, Smithsonian Institution. Smithsonian Contributions to Zoology. Number 56: 1-86.

Lewis, R.E. 1990. The Ceratophyllidae: Currently accepted valid taxa (Insecta: Siphonaptera). Theses Zoologicae, volume 13. R. Fricke [ed.] Koeltz Scientific Books. Koenigstein, Germany. 267 pp.

Beaucournu, J.C., J.A. Alcover and H. Launay. 1989. [The fleas (Siphonaptera) of the Canary Islands. Description of *Xenopsylla guancha* n. sp.] Vie et Milieu 39: 41-48.

Lewis, R.E. and J.H. Lewis. 1989. Catalogue of invalid genus-group and species-group names in the Siphonaptera (Insecta). These Zoologicae, Volume 11. R. Fricke [ed.]. Koeltz Scientific Books. Koenigstein, Germany. 263 pp.

Launay, H. and J.C. Beaucournu. 1987. African coptopsyllids (Siphonaptera): geographical distribution, morphology, taxonomical status and phyletic relationships with other members of the family. Ann. Parasitol. Hum. Comp. 62: 159-173.*

Beaucournu, J.C. and K. Kowalski. 1985. [New data on Algerian Siphonaptera.] Bull. Soc. Pathol. Exot. 78: 378-392.

Jordan, K. 1985. A contribution to the taxonomy of *Stenoponia* J. and R., 1911, a genus of Palaearctic and Nearctic fleas. Bull. Brit. Mus. Nat. Hist., Entomol. 6: 169 -202, figs. 1-30.

Traub, R., M. Rothschild and J.F. Haddow. 1983. The Rothschild collection of fleas. The Ceratophyllidae: key to the genera and host relationships. With notes on their evolution, zoogeography and medical importance. Published privately by M. Rothschild and R. Traub. Distributed by Academic Press. 288 pp.

Lewis, R.E. 1982. The insects of Saudi Arabia – Siphonaptera, pp 450-462. *In*: H.C.W. Wittmer and W. Büttiker, [eds.] Fauna of Saudi Arabia. Volume 4. Proc. Entomol. Nat. Hist. Mus., Basle.*

Beaucournu, J.C. 1979. [The fleas (Siphonaptera) of Morocco.] Bull. Inst. Scientifique 2: 85-86.

Beaucournu, J.C. and H. Hellal. 1977. [Annotated list of the Siphonaptera of Tunisia.] Bull. Soc. Path. Exot. 70: 524-537.

Beaucournu, J.C., N. Leger and G. Rosin. 1975. [Annotated list of Siphonaptera from Morocco.] Bull. Soc. Pathol. Filiales 68: 83-90.

Hastriter, M.W. and V.J. Tipton. 1975. Fleas (Siphonaptera) associated with small mammals of Morocco. J. Egypt. Publ. Hlth. Assoc. 50: 79 -169.*

Lewis, R. E. 1967. The fleas (Siphonaptera) of Egypt. An illustrated and annotated key. J. Parasitol. 53: 863-885.*

Snails

Brown, D.S. 1980. Freshwater snails of Africa and their medical importance. Taylor and Francis Ltd. London. 487 pp.*

Spiders

Denis, J. 1961. [Notes on the aranology of Morocco. IX. The arachnids of Morocco. I. Orthognatha and Haplogynae.] Bull. Soc. Sci. Natur. Phys. Maroc 41: 141-167.

Tabanidae

Leclercq, M. and J.M. Maldes. 1987. [List of the Tabanidae from Algeria and Morocco and a description of a new species (Diptera, Brachycera).] Nouv. Rev. Entomol. Toulouse 4: 79-84.*

Leclercq, M. 1968. [Tabanidae (Diptera) from Morocco. IV. Description of *Pangonius hassani* n. sp.] Bull. Rech. Agron. Gembloux 3: 703 -711.

Ticks (Ixodidae, Argasidae)

Farid, H.A. 1996. Morphological keys for the separation of the *Rhipicephalus sanguineus* group of ticks (Acarina: Ixodidae) in Egypt. J. Egypt. Soc. Parasitol. 26: 453-460.*

Hoogstraal, H. and M.N. Kaiser. 1960. Observations on ticks (Ixodoidea) of Libya. Ann. Entomol. Soc. Am. 53: 445-457.

Hoogstraal, H. 1956. Ticks of the Sudan (with s pecial reference to Equatoria Province and with preliminary reviews of the genera *Boophilus*, *Margaropus* and *Hyalomma*). Department of the Navy, Bureau of Medicine and Surgery, Washington, DC. 1101 pp.

Hoogstraal, H. and M.N. Kaiser. 1952. The ticks (Ix odoidea) of Egypt. NAMRU-3 Research Report NM 52 08, 03.3.07.

Appendix F: Personal Protective Measures

Personal protective measures are the first line of defense against arthropod-borne disease and, in some cases, may be the only protection for deployed military personnel. Proper wearing of the uniform and appropriate use of repellents can provide high levels of protection against blood-sucking arthropods. The uniform fabric provides a significant mechanical barrier to mosquitoes and other blood-sucking insects. Therefore, the uniform should be worn to cover as much skin as possible if weather and physical activity permit. When personnel are operating in tick-infested areas, they should tuck their pant legs into their boots to prevent access to the skin by ticks, chiggers, and other crawling arthropods. They should also check themselves frequently for ticks and immediately remove any that are found. If a tick has attached, seek assistance from medical authorities for proper removal or follow these guidelines from TIM 36, Appendix IX A.

1. **Grasp the tick's mouthparts** where they enter the skin, using pointed tweezers.

2. **Pull out** slowly and steadily with gentle force.

   a. Pull in the reverse of the direction in which the mouthparts are inserted, as you would for a splinter.

   b. **Be patient** – The long, central mouthpart (called the hypostome) is inserted in the skin. It is covered with sharp barbs, sometimes making removal difficult and time consuming.

   c. Many hard ticks secrete a cement-like substance during feeding. This material helps secure their mouthparts firmly in the flesh and adds to the difficulty of removal.

   d. It is important to continue to pull steadily until the tick can be eased out of the skin.

   e. **Do not** pull back sharply, as this may tear the mouthparts from the body of the tick, leaving them embedded in the skin. If this happens, don't panic. Embedded mouthparts are comparable to having a splinter in your skin. However, to prevent secondary infection, it is best to remove them. Seek medical assistance if necessary.

   f. **Do not** squeeze or crush the body of the tick because this may force infective body fluids through the mouthparts and into the wound.

   g. **Do not** apply substances like petroleum jelly, fingernail polish remover, repellent pesticides, or a lighted match to the tick while it is attached. These materials are either ineffective or, worse, may agitate the tick and cause it to salivate or regurgitate infective fluid into the wound site.

h. If tweezers are not available, grasp the tick's mouthparts between your fingernails, and remove the tick carefully by hand. Be sure to wash your hands -- especially under your fingernails -- to prevent possible contamination by infective material from the tick.

3. Following removal of the tick, **wash the wound** (and your hands) with soap and water and **apply an antiseptic**.

4. **Save the tick** in a jar, vial, small plastic bag, or other container for identification should you later develop disease symptoms. Preserve the tick by either adding some alcohol to the jar or by keeping it in a freezer. Storing a tick in water will not preserve it. Identification of the tick will help the physician's diagnosis and treatment, since many tick-borne diseases are transmitted only by certain species.

5. **Discard** the tick after one month; all known tick-borne diseases will generally display symptoms within this time period.

Newly developed repellents provide military personnel with unprecedented levels of protection. An aerosol formulation of permethrin (NSN 6840-01-278-1336) can be applied to the uniform according to label directions, but not to the skin. This will impart both repellent and insecticidal properties to the uniform material that will be retained through numerous washings. An extended formulation lotion of N, N-diethyl-m-toluamide (deet) (NSN 6840-01-284-3982) has been developed to replace the 2 oz. bottles of 75% deet in alcohol. This lotion contains 33% active ingredient. It is less irritating to the skin, has less odor and is generally more acceptable to the user. A properly worn Battle Dress Uniform (BDU) impregnated with permethrin, combined with use of extended duration deet on exposed skin, has been demonstrated to provide nearly 100% protection against a variety of blood-sucking arthropods. This dual strategy is termed the DoD ARTHROPOD REPELLENT SYSTEM. In addition, permethrin may be applied to bednets, tents, and other field items as appropriate. Complete details regarding these and other personal protective measures are provided in TIM 36, Personal Protective Techniques Against Insects and Other Arthropods of Military Significance (1996).

Appendix G
Bioscience and State Department Contacts in North Africa

1. Regional Contacts.

World Health Organization (WHO)
Regional Office for the Eastern Mediterranean
P.O. Box 1517
Alexandria – 21511
EGYPT

phone: [00203] 48-202-23 or 48-202-24
or 48 -202-90
FAX: [00203] 48-243-29

e-mail: <emro@who.sci.org>

Centers for Disease Control and Prevention
Division of Quarantine
National Center for Infectious Diseases
1600 Clifton Rd., NE
Atlanta, GA 30333
U.S.A.

phone: (404) 639-3311

e-mail: <netinfo@cdc.gov>

Officer in Charge
Naval Medical Research Unit (NAMRU) – 3
PSC 452, Box 131
FPO, AE 09835-00007

phone: (011) 202-284-1375 ext. 283

FAX: (011) 202-284-1382

2. Country Contacts

a. **Algeria**

Ambassador
4 Chemin Cheikh Bcchir El-Ibrahimi, Algiers
B.P. Box 549
Alger-Gare
16000 Algiers
ALGERIA

phone: [213] (2) 69-11-86 or 69-12-55
or 69-18-54 or 69-38-75

FAX: [213] (2) 69-39-79

b. **Canary Islands (via Spain)**

Ambassador
Serrano 75
28006, Madrid
SPAIN
APO, AE 09642

phone: [34] (1) 581-2200

FAX: [34] (1) 587-2303

c. **Egypt**

Ambassador (North Gate) 8 Kamel El-Din Salah Street Garden City, Cairo EGYPT	phone: [20] (2) 355-7371 FAX: [20] (2) 357-3200

d. **Morocco**

Ambassador 2 Avenue de Marrakech Rabat, MOROCCO PSC 74, Box 003 APO, **AE** 09718	phone: [212] (7) 76-22-65 FAX: [212] (7) 76-56-61

e. **Tunisia**

Ambassador 144 Avenue de la Liberté 1002 Tunis-Belvedere Tunis TUNISIA	phone: [216] (1) 782-566 FAX: [216] (1) 789-719

Appendix H: Glossary

acaricide - a substance developed to kill ticks and mites.
adulticide - insecticides used to kill the adult stages of an insect.
anaphylaxis - an unusual and severe allergic reaction of an organism to a foreign protein or other substances.
anthropophilic - the preference of insects and other arthropods to suck blood from humans rather than from animals.
autochthonous - transmission of a disease in the place where the disease occurred.
autogenous - not requiring a bloodmeal to produce eggs.
bionomics - the ecology of an organism.
biotope - a habitat characterized by environmental conditions and its community of animals and plants.
campestral - relating to fields or open country.
carrier - a person or animal that harbors infectious organisms, but is free of clinical disease. Generally synonymous with reservoir.
case fatality rate - the percentage of persons diagnosed as having a specific disease who die as a result of that illness within a given period.
cephalothorax - a body region consisting of head and thoracic segments.
cercariae - free-living stage in the life cycle of *Schistosoma* that emerges from snails and infects vertebrate hosts.
chelicerae - a pair of appendages used as mouthparts in arachnids such as scorpions, spiders, and ticks.
chemoprophylaxis - the administration of a chemical to prevent the development of an infection or the progression of an infection to active disease.
commensal - living in close association with another organism.
crepuscular - the twilight periods of light at dusk and dawn.
diapause - a period of arrested development and reduced metabolic rate, during which growth and metamorphosis cease.
diurnal - activities occurring during the daytime.
ectoparasite - a parasite that lives on the exterior of its host.
endemic - the constant presence of a disease or infection within a given geographic area.
endophagic - an arthropod that prefers to feed indoors.
endophilic - the tendency of arthropods to enter human structures.
enzootic - a disease that primarily infects animals and is present in an animal community at all times.
epidemic - the occurrence of cases of an illness (or an outbreak) that is clearly in excess of normal expectancy.
epizootic - an outbreak of a disease within an animal population.
eutrophic - rich in nutrients; usually applied to aquatic ecosystems.
exophagic - the tendency of an arthropod to feed outdoors.
exophilic - the tendency of blood-sucking arthropods to feed and rest outdoors.
facultative - not obligatory; characterized by the ability to adjust to circumstances.
family - a group of related genera.
focus (pl. foci) - a specific localized area.
genus (pl. genera) - a group of closely related species.

gonotrophic cycle - the time between feeding and oviposition.
inapparent infection - the presence of infection in a host without clinical symptoms.
incidence - the number of new cases of a specific disease occurring during a certain period of time.
incubation period - the time interval between initial contact with an infectious agent and the first appearance of symptoms associated with the infection.
indigenous - living or occurring naturally in a particular environment or area.
infection rate - the proportion (expressed as a percent) of a vector or host population that is infected.
infective - an organism that can transmit an infectious agent to another individual.
instar - an insect between successive molts.
larva (pl. larvae) - the immature stage, between the egg and pupa of an in sect, or the six-legged immature stage of a tick.
larvicide - insecticides used to kill larvae or immature stages of an insect.
larviparous - insects that deposit larvae rather than eggs on a host, food source, or other substrate.
maggot - legless larva of flies (Diptera).
mechanical transmission - the vector transmits the pathogen on contaminated mouthparts, legs, or other body parts, or by passage through the digestive tract without change.
miracidium (pl. miracidia) - ciliated, first larval stage in the life cycle of *Schistosoma* that penetrates and infects a snail, undergoing further development in the snail.
molluscicide - a chemical substance used for the destruction of snails and other molluscs.
myiasis - the invasion of hu man tissues by fly larvae.
night soil - human excrement used as fertilizer.
nosocomial - originating in a hospital or medical treatment facility.
nulliparous - a female arthropod that has not laid eggs.
nymph - an immature stage of an insect that does not have a pupal stage or an eight - legged immature tick or mite.
obligate - necessary or compulsory; characterized by the ability to survive only in a particular environment.
pandemic - a widespread epidemic disease distributed throughout a region or co ntinent.
parous - a female arthropod that has laid eggs.
pedipalps - the second pair of appendages of an arachnid.
periurban - relating to an area immediately surrounding a city or town.
prevalence - the total number of cases of a disease in existence at a certain time in a designated area.
pupa (pl. pupae) - a nonfeeding and usually inactive stage between the larval and adult stage.
quest (questing) - the behavior of ticks waiting in search of a passing host.
refractory - a host or vector that will not permit development or transmission of a pathogen.
reservoir - any animal, plant or substance in which an infectious agent survives and multiplies.
rodenticide - a chemical substance used to kill rodents, generally through ingestion.

ruminants - relating to a group of even-toed mammals such as sheep, goats and camels that chew the cud and have a complex stomach.
sequelae - any aftereffects of disease.
species complex - a group of closely related species, the taxonomic relationships o f which are sometimes unclear, making individual species identification difficult.
steppe - a vast, arid and treeless tract found in southeastern Europe or Asia.
sylvatic - related to a woodland or jungle habitat.
synanthropic - animals that live in close association with man.
synergist - a chemical that may have little or no toxicity in itself but, when combined with a pesticide, greatly increases the pesticide's effectiveness.
transovarial transmission - passage of a pathogen through the ovary to the next generation .
transstadial transmission - passage of a pathogen from one stage of development to another after molting.
ultra low volume (ULV) - the mechanical dispersal of concentrated insecticides in aerosols of extremely small droplets that drift with air currents.
urticaria - a reaction of the skin marked by the appearance of smooth, slightly elevated patches (wheals) that are redder or paler than the surrounding skin and often associated with severe itching.
vector - an organism that transmits a pathogen from one host to another.
vector competence - the relative capability of a vector to permit the development, multiplication and transmission of a pathogen.
vesicant - a blistering agent.
viremia - a virus that is present in the blood.
virulence - the degree of pathogenicity of an infectious agent.
wadi - a valley or bed of a stream in regions of southwest Asia and northern Africa that is dry except during the rainy season.
xerophilic - tolerant of dry environments.
zoonosis - an infectious disease of animals transmissible under natural conditions from nonhumans to humans.
zoophilic - the preference of insects and other arthropods to feed on animals other than humans.

Appendix I

Internet Websites on Medical Entomology and Vector-borne Diseases

A. Primary Sites

1. Emerging diseases website, with current information on disease outbreaks.
<http://www.outbreak.org>

2. Iowa State University's comprehensive site on medical entomology with excellent information on links to over 20 additional sites.
<http://www.iastate.edu/list/medical_entomology.html>

3. The Defense Pest Management Information Analysis Center's database. Provides on-line access to the available literature, published and unpublished, on medical entomology, insects, arachnids, and pest management. On-line access to abstracts, with additional information on ordering complete articles to eligible users.
<http://www.afpmb.org/lrs>

4. WHO disease outbreak information – emerging and communicable disease information from the WHO and its databases. The tropical medicine databases are the most useful for vector-borne diseases. Access can also be obtained to the Weekly Epidemiological Record.
<http://www.who.int/emc/index.html>

5. The Walter Reed Biosystematic Unit's online inf ormation regarding taxonomic keys, diseases transmitted by mosquitoes, and mosquito identification modules.
<http://wrbu.si.edu/>

6. Centers for Disease Control – information on the CDC's travel alerts, including access to country health profiles, vaccine recommendations, State Department entry requirements, and publications.
<http://www.cdc.gov/travel/index.html>

7. The National Library of Medicine's biomedical databases, especially Medline. Provides complete references and abstracts to more than 9 million journal articles from biomedical publications.
<http://www.nlm.nih.gov/>

8. The Malaria Foundation International's site for general resources on malaria available through the worldwide web. Includes references, malaria advisories, and lists of other malaria websites.
<http://www.malaria.org>

9. The WHO site for information on vector-borne diseases, including disease distribution, information on disease outbreaks, travel alerts, WHO research programs,

and progress on control.
<http://www.who.ch/>

10. The CDC's site on information available on encephalitis, as published in the Morbidity and Mortality Weekly Report. Includes case definition and disease outbreak information.
<http://www.cdc.gov/epo/mmwr/other/case_def/enceph.html>

11. Information from the University of Florida's website on mosquitoes and other biting flies.
<http://hammock.ifas.ufl.edu/text/ig/8804.html>

12. Information on ticks and other ectoparasites from the University of Rhode Island's Tick Research Laboratory.
<http://www.uri.edu/artsci/zool/ticklab/>

13. Information on plague available from the CDC's Morbidity and Mortality Weekly Report.
<http://www.cdc.gov/epo/mmwr/other/case_def/plague.html>

13. A list of websites and servers pertaining to entomology from Colorado State University. Over 30 websites are listed.
<http://www.colostate.edu/Depts/Entomology/ent.html>

14. The Vero Beach website offers information on research on mosquitoes through the American Mosquito Control Association, details on mosquito information, as well as links to other related sites.
<http://www.ifas.ufl.edu~veroweb/links.htm>

B. Additional Sites

1. Lyme Disease Network – information on Lyme disease, including research abstracts, treatments for Lyme disease, newsletter, conferences, and professional resources.
<http://www.lymenet.org>

2. The USDA plant database – includes the integrated taxonomic information system.
<http://plants.usda.gov/ >

3. University of Sydney, Medical Entomology – contains information on mosquito keys, fact sheets, and photos of mosquitoes.
<http://medent.usyd.edu.au>

4. American Society of Tropical Medicine and Hygiene – information on the ASTMH's programs, conferences, newsletters, publications, and resources.
<http://www.astmh.org >

5. The American Mosquito Control Association's site containing information on mosquito biology, AMCA programs, conferences, newsletters, publications, and resources. <http://www.mosquito.org>

6. Reuters search engine on health news pertaining to health issues around the world. <http://www.reutershealth.com/>

7. The ORSTOM home page includes information about the organization's medical research program in Asia, Africa, and Latin America. Bulletins and publications on its research are offered.
<http://www.orstom.fr/>

8. Emory University's website allows access to the Univer sity's extensive database of medical and scientific literature.
<http://www.medweb.emory.edu/medweb/>

9. The Entomological Society of America offers information on its overall services, including conferences, journals, references, membership, and literature available for ordering.
<http://www.entsoc.org>

10. Travel Health Online contains country profiles with health precautions and disease risk summaries, general travel health advice, contacts for providers of pretravel health services, and access to US State Department publications.
<http://www.tripprep.com>

APPENDIX J METRIC CONVERSION TABLE

Metric System

LINEAR MEASURE

10 millimeters	=	1 centimeter
10 centimeters	=	1 decimeter
10 decimeters	=	1 meter
10 meters	=	1 decameter
10 decameters	=	1 hectometer
10 hectometers	=	1 kilometer

AREA MEASURE

100 sq. millimeters	=	1 sq. centimeter
10,000 sq. centimeters	=	1 sq. meter
1,000,000 sq. millimeters	=	1 sq. meter
100 sq. meters	=	1 are
100 ares	=	1 hectare
100 hectares	=	1 sq. kilometer
1,000,000 sq. meters	=	1 sq. kilometer

VOLUME MEASURE

1 liter	=	0.001 cubic meter
10 milliliters	=	1 centiliter
10 centiliters	=	1 deciliter
10 deciliters	=	1 liter
10 liters	=	1 decaliters
10 decaliters	=	1 hectoliter
10 hectoliters	=	1 kiloliter

WEIGHT

10 milligrams	=	1 centigram
10 centigrams	=	1 decigram
10 decigrams	=	1 gram
10 grams	=	1 decagram
10 decagrams	=	1 hectogram
10 hectograms	=	1 kilogram
1,000 kilograms	=	1 metric ton

U.S. Customary System

LINEAR MEASURE

12 inches	=	1 foot
3 feet	=	1 yard
5 ½ yards	=	1 rod
40 rods	=	1 furlong
8 furlongs	=	1 mile
3 land miles	=	1 league

AREA MEASURE

144 sq. inches	=	1 sq. foot
9 sq. feet	=	1 sq. yard
30 ¼ sq. yards	=	1 sq. rod
160 sq. rods	=	1 acre
640 acres	=	1 sq. mile
1 sq. mile	=	1 section
36 sections	=	1 township

LIQUID MEASURE

4 gills (2 cups)	=	1 pint
2 pints	=	1 quart
4 quarts	=	1 gallon

DRY MEASURE

2 pints	=	1 quart
8 quarts	=	1 peck
4 pecks	=	1 bushel

WEIGHT

27 11/32 grains	=	1 dram
16 drams	=	1 ounce
16 ounces	=	1 pound
100 pounds	=	1 hundredweight
20 hundredweight	=	1 ton

Kitchen Measurements

3 tsp.	= 1 tbsp.	5 1/3 tbsp.	= 1/3 cup	2 cups	= 1 pint	2 pints	= 1 quart
4 tbsp.	= ¼ cup	16 tbsp.	= 1 cup	4 cups	= 1 quart	4 quarts	= 1 gallon

Temperature

$$\text{Celsius} = \frac{5}{9}(F - 32) \qquad \text{Fahrenheit} = \frac{9C}{5} + 32$$

°C	100	90	80	70	60	50	40	35	30	25	20	15	10	5	0	-5	-10	-15	-20	-25	-30	-40
°F	212	194	176	158	140	122	104	95	86	77	68	59	50	41	32	23	14	5	-4	-13	-22	-40

Conversion Table

To convert	Into	Multiply by
Centimeters	Inches	.394
	Feet	. 0328
	Meters	.01
	Millimeters	10
Meters	Centimeters	100
	Feet	3.281
	Inches	39.37
	Kilometers	.001
	Miles	.0006214
	Millimeters	1000
	Yards	1.093
Kilometers	Feet	3281
	Meters	1000
	Miles	.621
	Yards	1093

To convert	Into	Multiply by
Liters	Cups	4.226
	Pints	2.113
	Gallons	. 264
	Milliliters	1000
	Quarts	1.057
Grams	Ounces	. 035
	Pounds	002
	Kilograms	. 001
Kilograms	Grams	1,000
	Ounces	35.274
	Pounds	2.205
Inches	Centimeters	2.54
	Feet	.0833
	Meters	.0264
	Yards	.0278
Yards	Inches	36
	Feet	3
	Meters	. 914
	Miles	. 0005682

To convert	Into	Multiply by
Miles	Feet	5,280
	Yards	1,760
	Kilometers	1,609
Pints	Liters	.473
	Quarts	.5
	Gallons	.125
Quarts	Pints	2
	Liters	.946
	Gallons	.25
Gallons	Pints	8
	Liters	3.785
	Quarts	4
Ounces	Grams	28.35
	Pounds	.0625
	Kilograms	.028
Pounds	Grams	453.59
	Ounces	16
	Kilograms	.454